Espey, Huston & Associates, Inc.
Engineering & Environmental Consultants

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BENTHIC MACROINFAUNAL ANALYSIS OF DREDGED MATERIAL PLACEMENT AREAS IN THE LAGUNA MADRE, TEXAS SPRING AND FALL 1996 SURVEYS

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1.0 INTRODUCTION

Concerns have been expressed about environmental impacts from the open-water placement of dredged material in the Laguna Madre by State and Federal agencies and various citizen groups Potential impacts, from both burial and elevated turbidity from placement activities and resuspension, include reduced functions of benthos and, therefore, an impact on the ecosystem, especially in terms of trophic support for commercial and recreational fisheries. An Interagency Coordination Team (ICT), comprising representatives from numerous State and Federal agencies, has been formed to determine if sufficient information exists to address the issues of concern and, if so, to address them.

Portions of the Gulf Intracoastal Waterway (GIWW) through the Laguna Madre require periodic maintenance dredging due to shoaling Studies are underway to study other aspects of potential impacts from dredging and placement in the Laguna Madre, e g , studies on sea grasses and habitat utilization and support for fisheries This study was to look directly at the benthic community and impacts to that community from placement of dredged material.

Benthic macroinfaunal community composition was monitored in Laguna Madre, Texas in conjunction with evaluation of environmental impacts of the historic practice of open-water placement of dredged material. Study design, field sampling, and final report review/preparation were provided by Espey, Huston & Associates (EH&A) while infaunal analyses, data interpretation, and initial report preparation were conducted by Barry A. Vittor & Associates, Inc (BVA) The objectives of this survey were to describe benthic community composition, and to quantify basic community characteristics such as species and individual abundance, diversity, and evenness Infaunal and sediment data were to be used to determine whether the placement of dredged material had an adverse impact on the benthic resources of Laguna Madre. This report discusses the results of the Spring 1996 and Fall 1996 surveys.

2.0 PURPOSE

The purpose of this study is to characterize the benthic community, at two different times of the year, in and near Placement Areas (PAs) in the Upper and Lower Laguna Madre (figures 1 and 2) and at reference sites across the Gulf Intracoastal Waterway (GIWW) from the selected PAs The PAs were selected to depict (1) heavy, moderate, and light usage and (2) deep, non-vegetated and shallow, vegetated habitats. Therefore, the benthos of the Laguna Madre will be characterized, and comparison can be made between existing PAs and across-GIWW reference sites and between existing PAs and same-side sites out of the PAs.

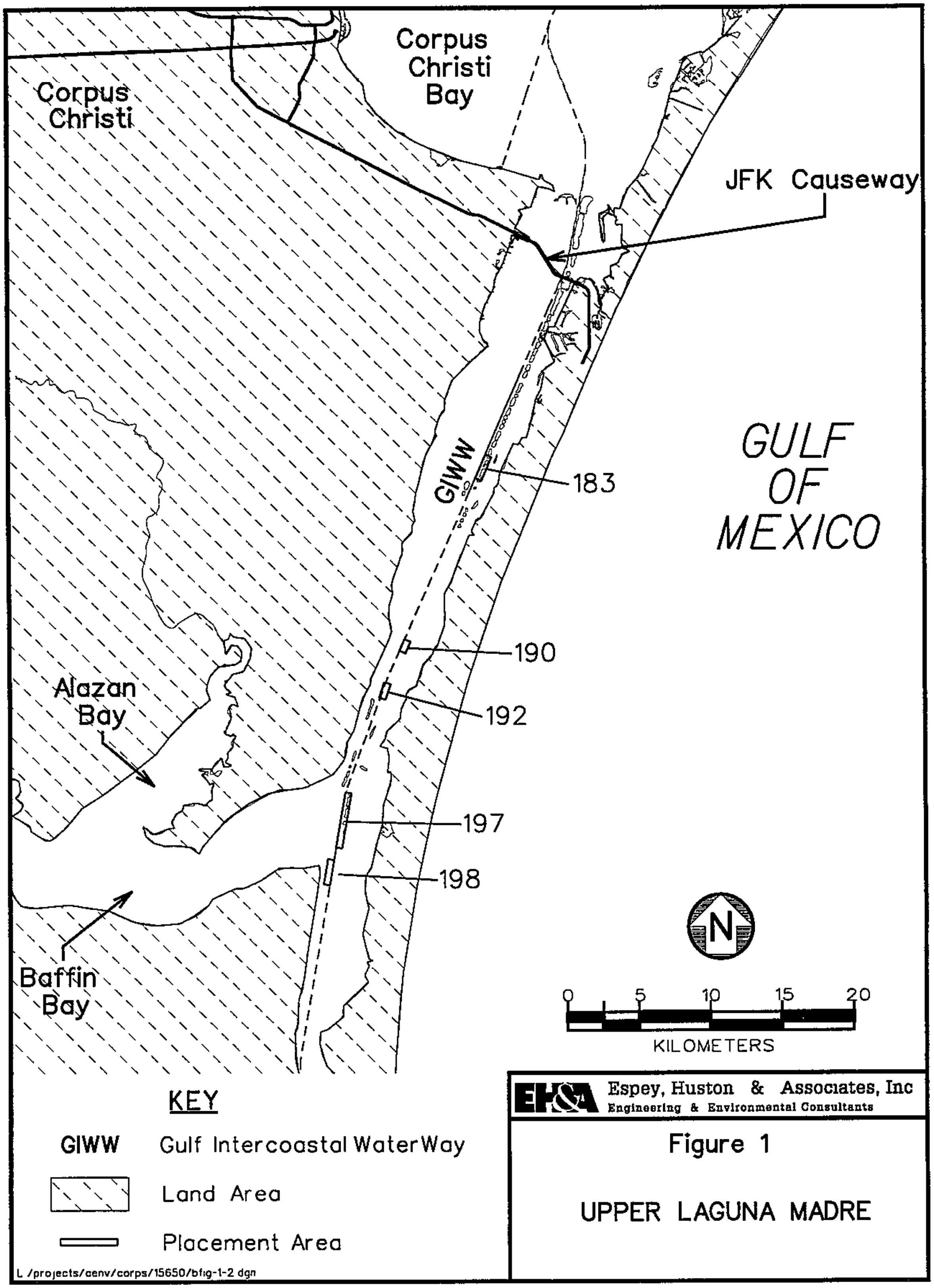

Figure 1

UPPER LAGUNA MADRE

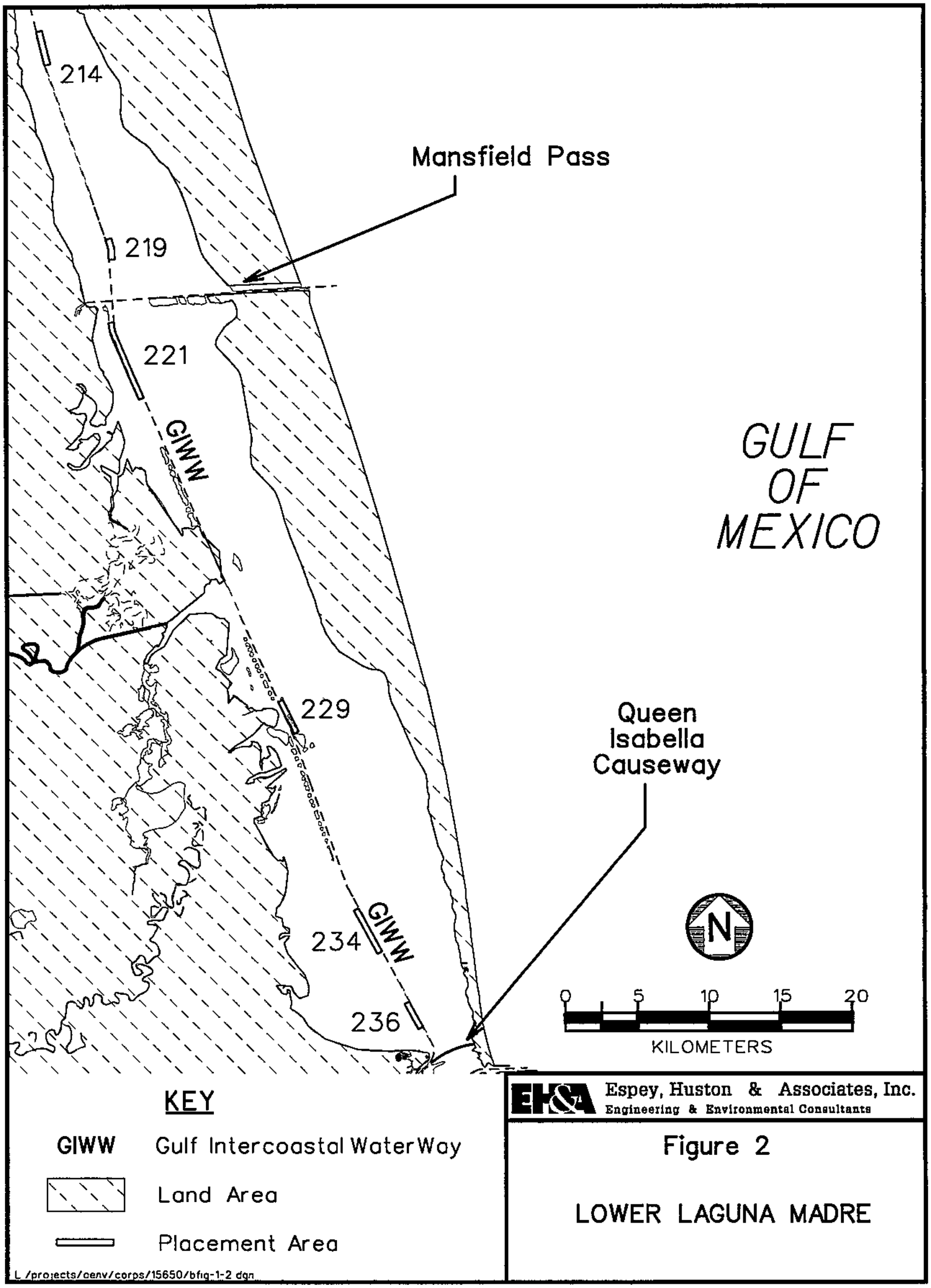

Figure 2

LOWER LAGUNA MADRE

3.0 METHODS

3 1 SAMPLING LOCATIONS

Six PAs were selected in both the Upper and Lower Laguna Madre by EH&A, the U.S. Army Corps of Engineers (USACE) and the National Marine Fisheries Service (NMFS) personnel The following PAs were selected·

	Upper Laguna	Lower Laguna
Low-Use Vegetated	PA183A	PA229
Low-Use Unvegetated	PA183B	PA236
Medium-Use Vegetated	PA190	PA214
Medium-Use Unvegetated	PA192	PA219
High-Use Vegetated	PA197	PA221
High-Use Unvegetated	PA198	PA234

Note that PA183 was used both as the vegetated and unvegetated PA for Low Use in the Upper Laguna Madre.

The Scope of Work noted that at each PA, two randomly-selected stations were to be occupied in the northern third of the PA (Stations N1 and N2), the middle third (Stations M1 and M2), and the southern third (Stations S1 and S2, Figure 3) Additionally, two stations parallel to the longitudinal axis, north and south of the north-south midpoint were to be occupied for each PA, at 250 feet, or more, from the non-GIWW edge of the PA (Stations MD1 and MD2) Seven reference stations were to be located directly across, and at roughly the same distance from, the GIWW as the PA stations (RN1, RN2, RM1, RM2, RS1, RS2, and RD) In practice, stations located in the field did not precisely match the plan presented in the Scope of work because of the fact that the PAs were not as depicted on maps, inaccuracies in the GPS unit, extremely shallow water depths in some areas, and attempting to avoid people who were actively fishing.

According to the Scope of Work, this station array would allow several types of analyses. The in-PA stations could be compared to the reference stations on the other side of the GIWW for indications of direct results of dredged material disposal This would yield information on recovery after burial and would be expected to be related to time since disposal The reference stations would allow a

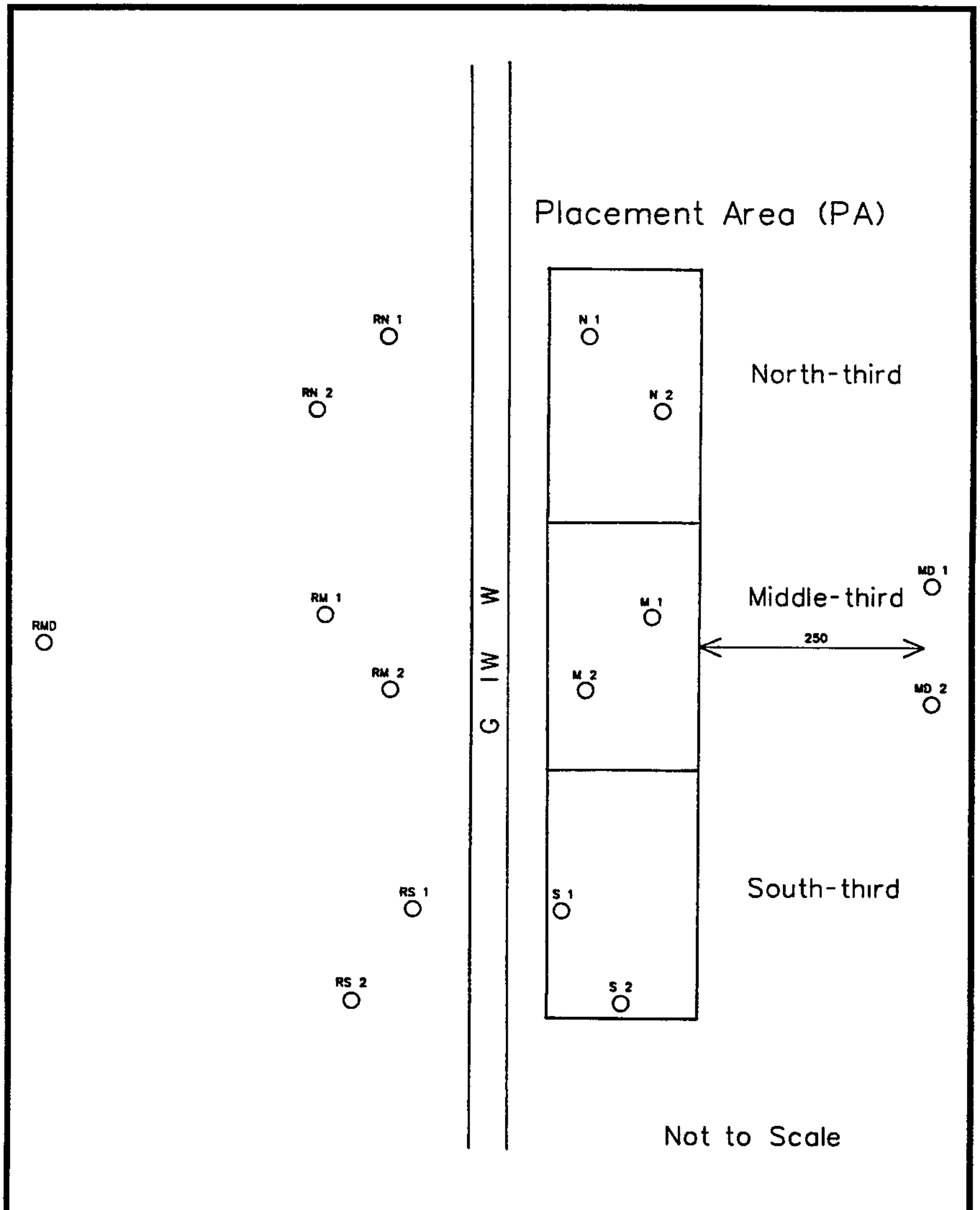

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Figure 3

Conceptual Stations

File L /projects/oenv/corps/15650/con-stat.dgn characterization of various Laguna Madre locations and habitats The MDs would, depending on circumstances, allow characterization of a station with reduced, or no, influence from dredged material placement

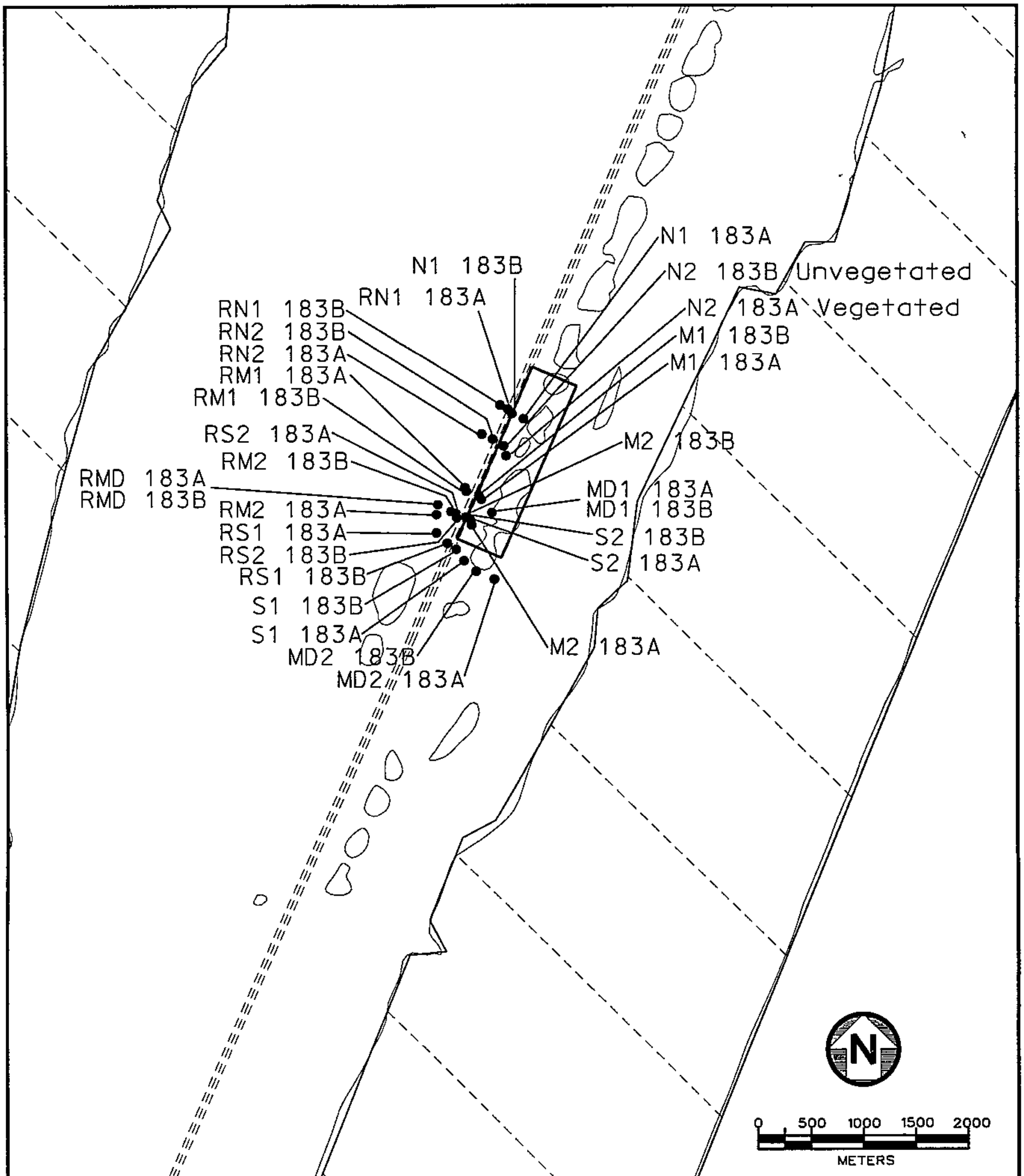
At each station, one grab was taken for benthos analysis and one for grain size analysis Standard parameters which influence the benthic community structure, e.g., temperature, salinity, pH, dissolved oxygen, Secchi depth, and water depth, were taken at each PA

For the Spring sampling, benthic samples were collected at 47 stations arranged within 11 PAs during the period of May 14 - May 30, 1996 (figures 4 - 10, tables 1 and 2). A total of 178 macroinfauna and sediment texture samples was collected (MD1 and RMD at PAs 183A and 183B were the same), primarily using an Ekman grab with a surface area of 0.023 m^2. In some areas where the Ekman grab could not penetrate the bottom, other devices were used, including a post-hole digger The sample sizes with these alternative methods were different than the Ekman grab size, and ranged from 0.014 m^2 to 0 047 m^2.

For the Fall sampling, benthic samples were collected at 49 stations during the period of September 23 - October 3, 1996 (figures 11-17, tables 3 and 4) In all, 177 macroinfauna and sediment texture samples were collected (MD1, MD2, and RMD at PAs 183A and 183B were the same), almost exclusively with a post-hole digger (0.014 m^2 area). The Ekman grab was used at Placement Area 219, Station N1 because the water was too deep for the post-hole digger In the Spring sampling, several sampling techniques had been used While EH&A and BVA feel that the Spring data were sound, it did require extra effort in data analysis Therefore, in an attempt to standardize the sample size, the post-hole digger was used as the sampler of choice in the Fall

3.2 SEDIMENT SAMPLING

As noted above, sediment texture samples were taken from separate grab/core samples at each of the sampling points and shipped to Anacon, Inc , for grain size analysis Sediment grain size was determined using standard sieve/hydrometer methods



KEY

GIWW	Gulf Intracoastal WaterWay
	Land Area
	Placement Area
•	Station

File L /projects/aenv/corps/15650/bfig-4 dgn

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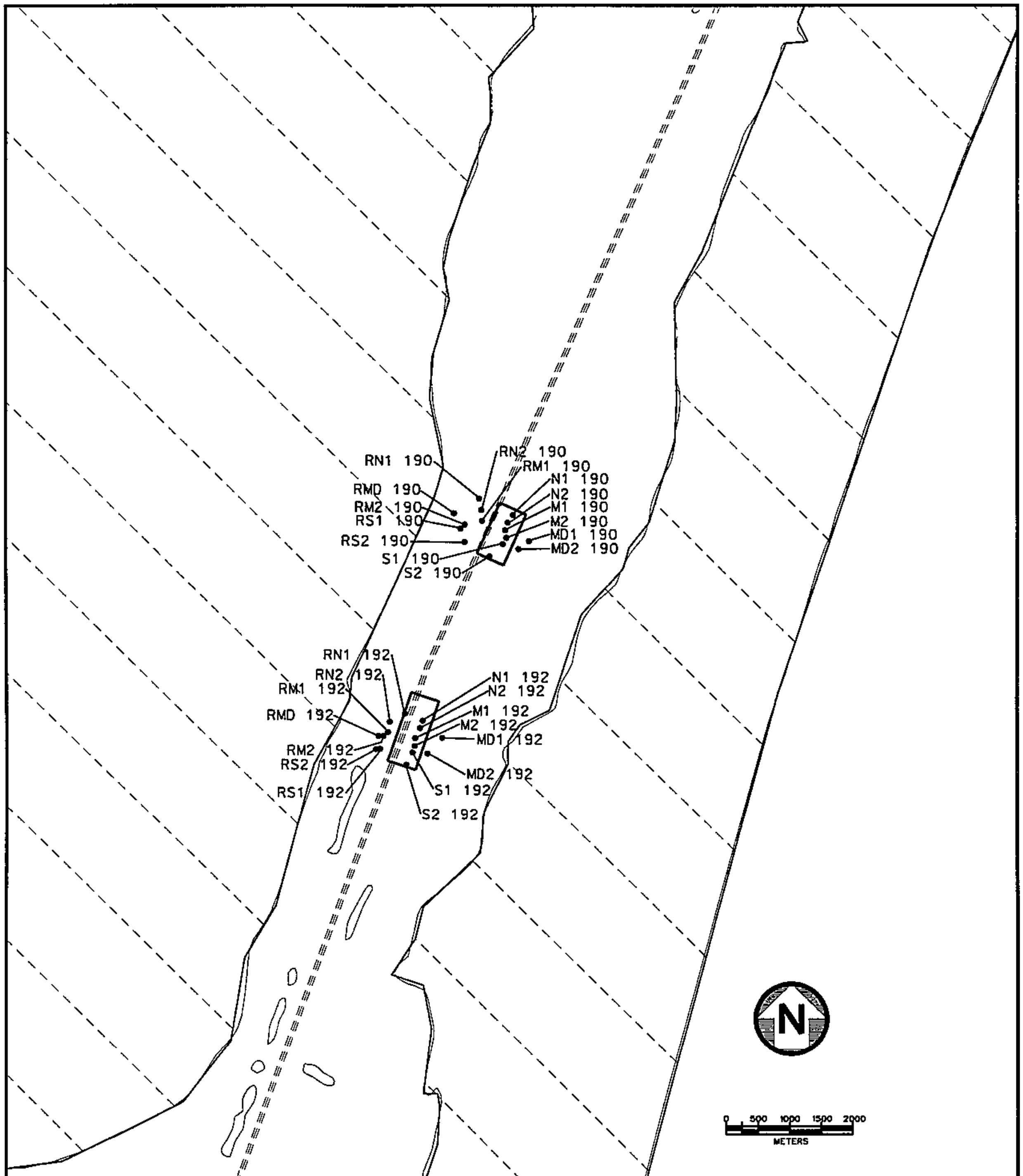
Figure 4

PA NO. 183
Spring 1996



KEY

GIWW Gulf Intracoastal WaterWay

Land Area

Placement Area

• Station

File L /projects/aenv/corps/15650/bfig-5 dgn

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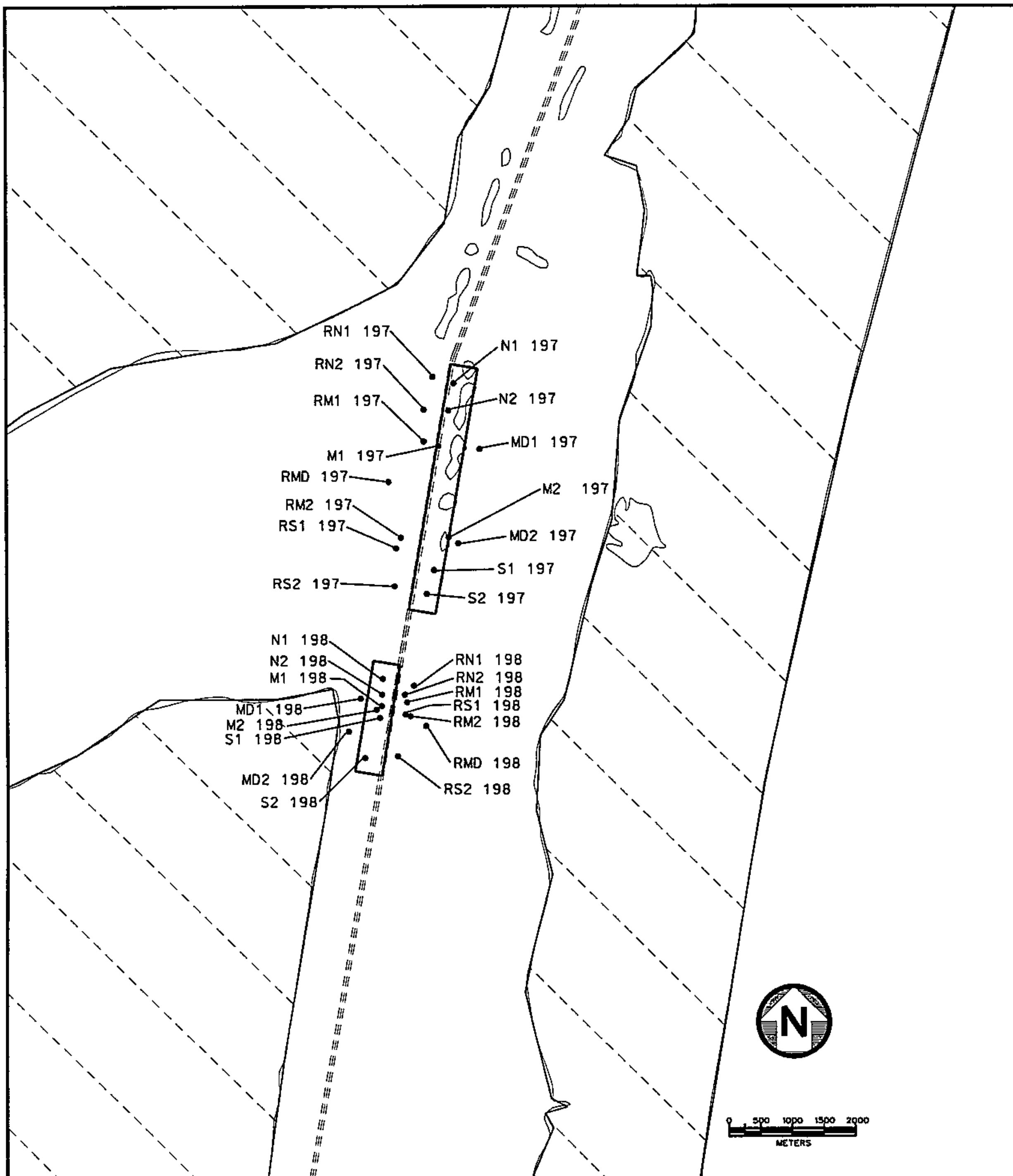
Figure 5

PA NOS. 190 and 192
Spring 1996



KEY

GIWW	Gulf Intracoastal WaterWay
(hatched box)	Land Area
(double line)	Placement Area
•	Station

File L /projects/oenv/corps/15650/bfig-6 dgn

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Figure 6

PA NOS. 197 and 198
Spring 1996

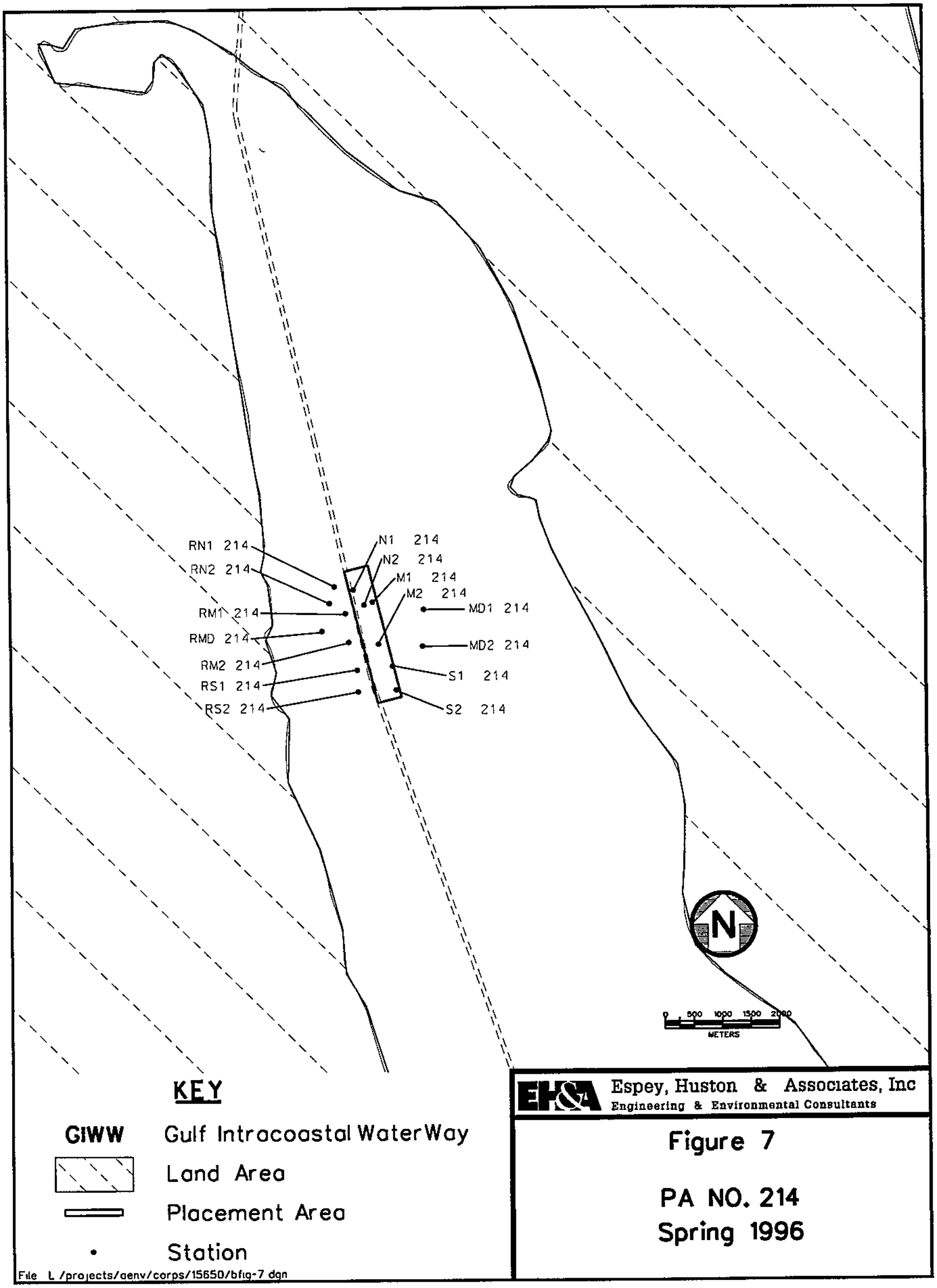
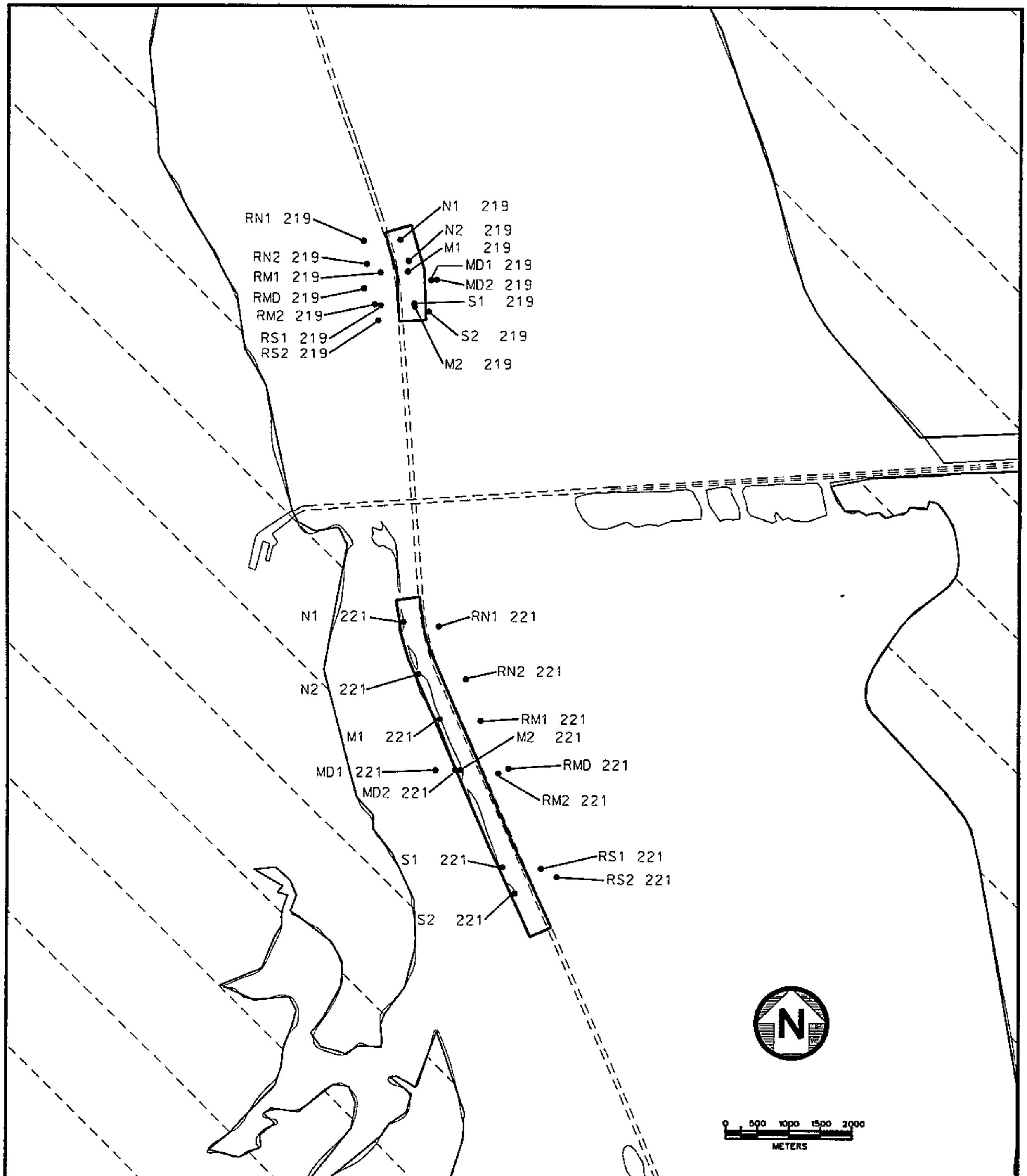


Figure 7

PA NO. 214
Spring 1996



KEY

GIWW Gulf Intracoastal WaterWay

Land Area

Placement Area

• Station

File L /projects/aenv/corps/15650/bfig-8 dgn

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Figure 8

PA NOS. 219 and 221
Spring 1996

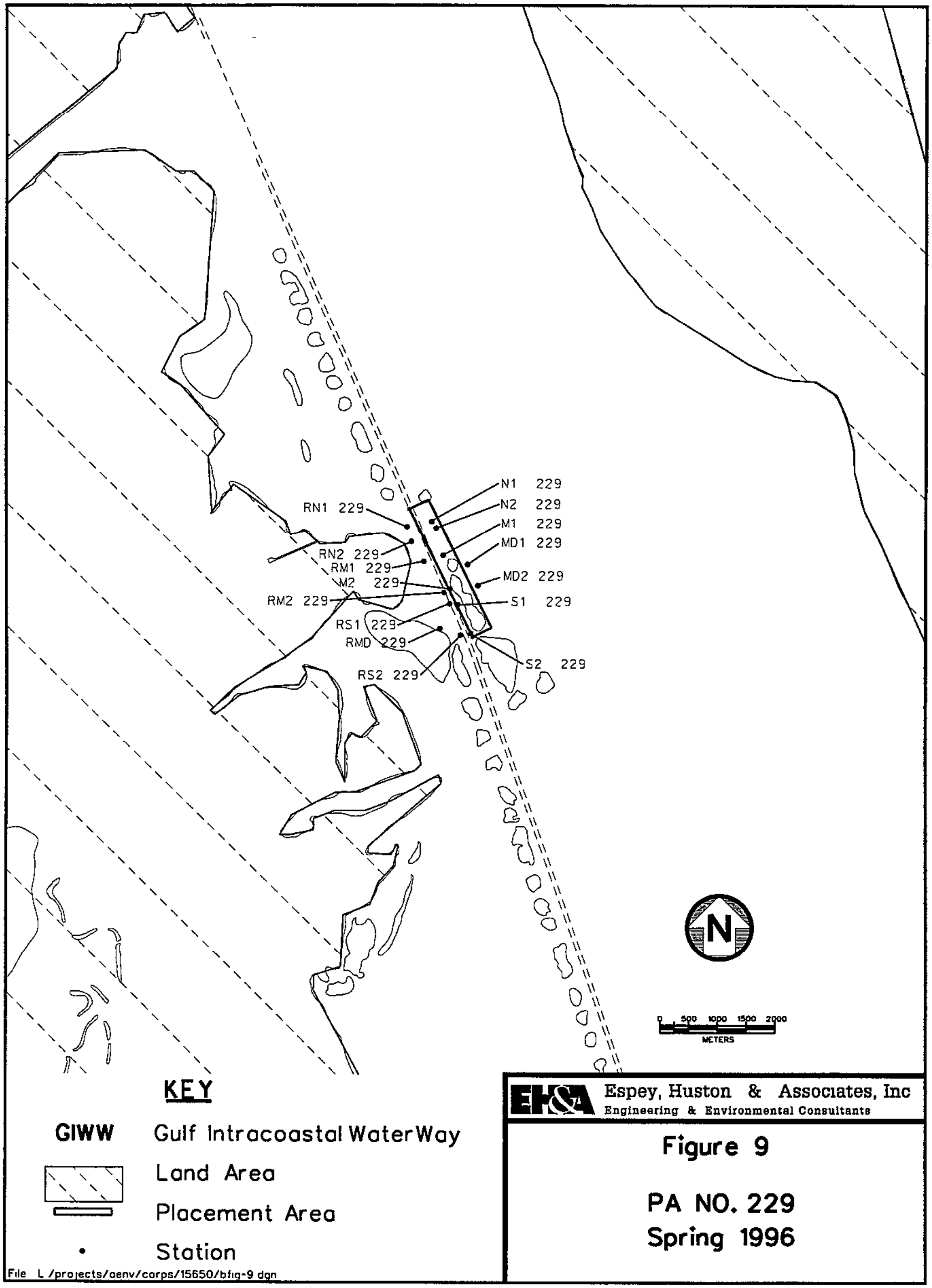
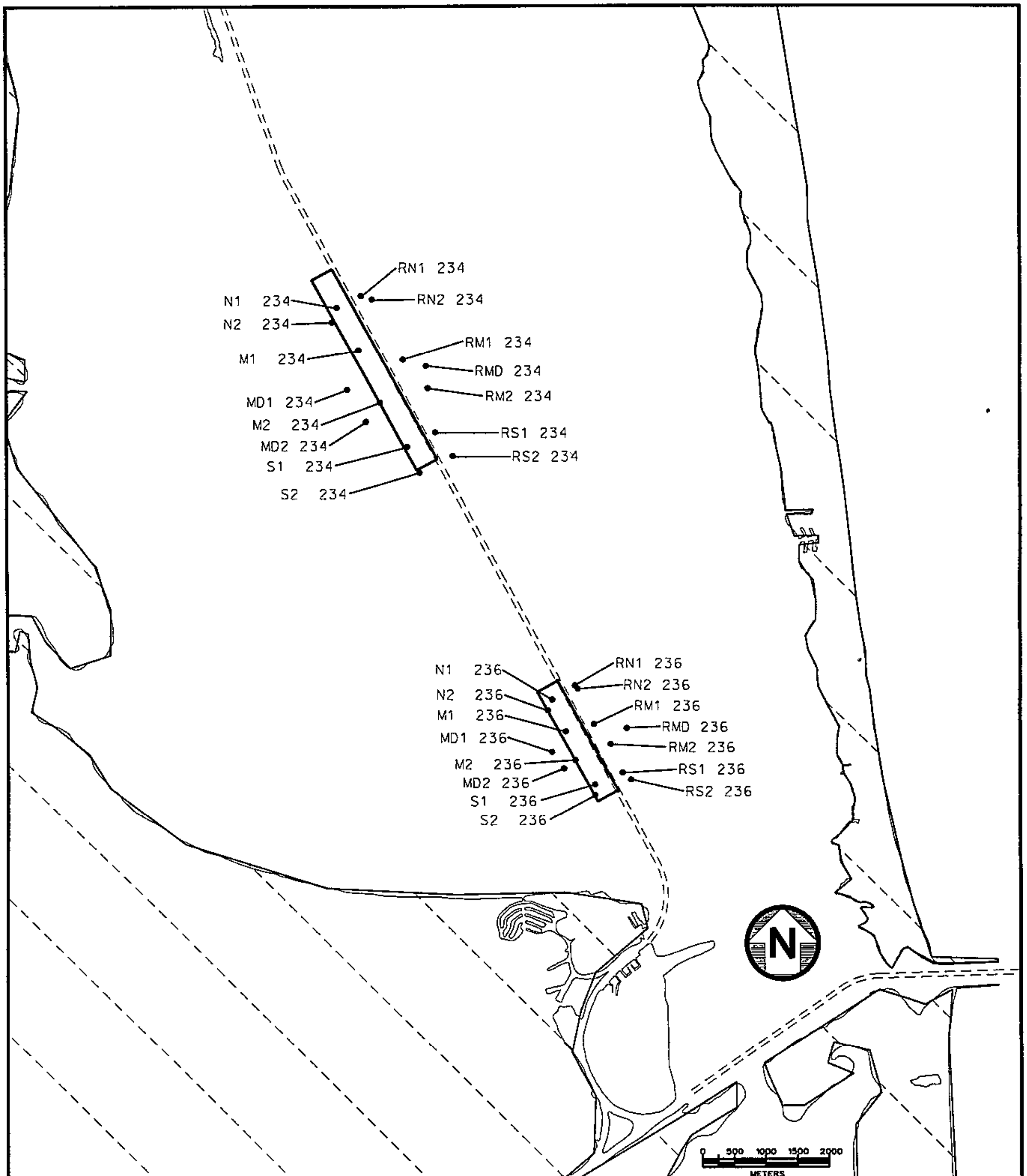


Figure 9

PA NO. 229
Spring 1996



KEY

GIWW Gulf Intracoastal WaterWay

Land Area

Placement Area

• Station

File L /projects/aenv/corps/15650/bfig-10 dgn

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Figure 10

PA NOS. 234 and 236
Spring 1996

TABLE 1
Station Locations and Descriptions Benthos Survey May 1996
Upper Laguna Madre

Placement Area	Station	Depth (feet)	North Degrees	North Minutes	North Seconds	West Degrees	West Minutes	West Seconds	Sampler	Seagrass	Secchi (cm)	Comments
183A	N1	2.6	27	31	9 2	97	18	0 3	phd	Hw	28	Green 97
Vegetated	N2	2 4	27	30	56 3	97	18	2 7	phd	Hw	32	Green 99 stone crab
	M1	2 1	27	30	42 9	97	18	11 7	phd	Hw	25	
5/28/96	M2	2 2	27	30	34 8	97	18	15 2	phd	Hw	27	Near Rm beds
	MD1	1 1	27	30	33 0	97	18	10 4	phd	Hw, Rm Sf	ND	
	MD2	1 9	27	30	17 7	97	18	7 9	Ekman	Hw	22	
	S1	2 1	27	30	23 7	97	18	18 2	Ekman	Hw	21	Green 103
	S2	2 3	27	30	36 3	97	18	15 5	Ekman		23	Between Cans 101 &103
	RN1	2 3	27	31	10 6	97	18	1 7	phd	Hw	26	
	RN2	2 1	27	30	59 7	97	18	7 8	phd	Hw	25	
	RM1	2 6	27	30	46 7	97	18	17 3	phd	Hw	28	
	RM2	2 5	27	30	38 4	97	18	27 2	phd	Hw	22	
	RMD	2 5	27	30	41 5	97	18	26 7	Ekman	Hw	17	
	RS1	2 3	27	30	32 6	97	18	27 4	Ekman	Hw	21	
	RS2	4 9	27	30	38 6	97	18	20 6	Ekman		20	
183B	N1	4 8	27	31	12 2	97	18	4 5	phd		28	Green 97
Unvegetated	N2	5 0	27	30	59 3	97	18	3 5	phd		24	Green 99
	M1	5 2	27	30	44 2	97	18	12 5	phd		27	
5/28/96	M2	4 8	27	30	37 3	97	18	17 2	phd		27	
	MD1	1 1	27	30	33 0	97	18	10 4	phd	Hw, Rm, Sf	ND	
	MD2	1 6	27	30	20 3	97	18	14 1	Ekman	Hw	24	Tried to get sample in bare patch
	S1	4 9	27	30	27 3	97	18	20 8	Ekman		20	
	S2	5 0	27	30	37 1	97	18	16 3	Ekman		16	T=31 9 DO=8 4 S=39 9
	RN1	5 0	27	31	11 9	97	18	4 3	phd		26	
	RN2	4 5	27	31	1 5	97	18	7 2	phd		24	
	RM1	5 0	27	30	45 6	97	18	16 8	phd		25	
	RM2	4 7	27	30	39 2	97	18	22 2	Ekman		27	
	RMD	2 5	27	30	41 5	97	18	26 7	Ekman	Hw	17	
	RS1	4 7	27	30	29 3	97	18	23 8	Ekman		21	
	RS2	4 9	27	30	37 2	97	18	20 3	Ekman		19	
190	N1	1 7	27	24	20 5	97	21	23 8	phd	Hw	28	
	N2	2 7	27	24	16 7	97	21	26 9	phd	Hw	30	
	M1	2 1	27	24	12 8	97	21	28 5	phd	Hw	27	
5/30/96	M2	1 1	27	24	8 8	97	21	28 0	phd	Hw	31	
	MD1	4 6	27	24	6 9	97	21	14 8	phd	He	28	
	MD2	4 8	27	24	2 9	97	21	21 0	phd	Hw	29	Just a few sprigs of Hw
	S1	1 4	27	24	5 6	97	21	30 0	phd	Hw	ND	
	S2	2 1	27	23	59 5	97	21	37 9	phd	Hw	29	
	RN1	4 2	27	24	29 3	97	21	43 2	phd	He	29	
	RN2	4 3	27	24	23 5	97	21	42 0	phd	He	28	
	RM1	4 0	27	24	17 9	97	21	41 7	phd	Hw He	28	
	RM2	3 3	27	24	16 2	97	21	51 8	phd	Hw	29	
	RMD	3 2	27	24	22 1	97	21	57 8	phd	Hw	27	
	RS1	3 3	27	24	14 1	97	21	54 2	phd	Hw	29	
	RS2	3 2	27	24	7 2	97	21	52 1	phd	Hw	29	

TABLE 1 (Concluded)

Placement Area	Station	Depth (feet)	North Degrees	North Minutes	North Seconds	West Degrees	West Minutes	West Seconds	Sampler	Seagrass	Secchi (cm)	Comments
192	N1	1 7	27	22	34 9	97	22	18 5	phd	Hw	26	
	N2	4 7	27	22	31 1	97	22	20 1	phd		27	
	M1	2 9	27	22	25 9	97	22	23 1	phd	Hw	31	
5/30/96	M2	1 4	27	22	21 8	97	22	23 5	phd	Hw	30	
	MD1	5 7	27	22	25 8	97	22	7 5	phd		26	
	MD2	4 1	27	22	17 8	97	22	16 3	phd	Hw, He	30	Due east of Green 175
	S1	1 3	27	22	18 5	97	22	24 7	phd	Hw	31	
	S2	4 0	27	22	12 2	97	22	28 6	phd		26	
	RN1	1 3	27	22	38 9	97	22	28 6	phd	Hw	33	
	RN2	3 6	27	22	34 8	97	22	37 4	phd	Hw	26	
	RM1	3 6	27	22	29 5	97	22	38 6	phd	Hw, He	27	
	RM2	3 7	27	22	27 5	97	22	41 1	phd	Hw, He	26	
	RMD	3 6	27	22	27 6	97	22	44 0	phd	Hw, He	22	
	RS1	3 6	27	22	20 9	97	22	43 3	phd	Hw	20	
	RS2	3 7	27	22	20 8	97	22	45 6	phd	Hw, He	26	
197	N1	1 2	27	18	27 5	97	24	10 1	phd	Hw	16	
	N2	1 8	27	18	13 6	97	24	13 5	phd	Hw	16	Green 211
	M1	2 0	27	17	55 5	97	24	19 8	phd	Hw	24	Green 213
5/29/96	M2	2 4	27	17	8 3	97	24	15 2	phd		20	First island cut
	MD1	3 0	27	17	53 5	97	23	56 2	phd		20	
	MD2	4 8	27	17	5 0	97	24	9 8	phd		29	
	S1	5 3	27	16	51 5	97	24	24 0	phd		25	
	S2	6 4	27	16	39 0	97	24	28 5	phd		30	
	RN1	2 8	27	18	31 0	97	24	22 0	phd	Hw	23	
	RN2	2 6	27	18	14 3	97	24	27 7	phd	Hw	19	
	RM1	2 5	27	17	58 0	97	24	28 1	phd	Hw	25	Anaerobic sandy
	RM2	5 3	27	17	8 6	97	24	42 7	phd		21	
	RMD	3 0	27	17	37 5	97	24	49 0	phd	He	17	
	RS1	6 9	27	17	3 1	97	24	45 5	phd		22	
	RS2	8 2	27	16	43 4	97	24	46 9	phd		21	
198	N1	5 6	27	15	55 5	97	24	55 2	phd		30	
	N2	7 3	27	15	47 4	97	24	55 7	phd		33	
	M1	7 1	27	15	41 5	97	24	56 1	phd		39	
5/29/96	M2	6 9	27	15	39 6	97	24	59 0	phd		36	
	MD1	5 4	27	15	45 5	97	25	8 1	phd		25	
	MD2	4 9	27	15	28 7	97	25	15 4	phd		28	
	S1	7 1	27	15	35 4	97	24	57 3	phd		37	
	S2	4 0	27	15	14 8	97	25	6 5	phd		32	0800 Tide at 1 8 MLT
	RN1	6 7	27	15	51 6	97	24	37 2	phd		30	
	RN2	5 1	27	15	35 9	97	24	39 6	phd		36	
	RM1	5 5	27	15	43 1	97	24	41 4	phd		24	
	RM2	5 5	27	15	47 1	97	24	42 6	phd		26	
	RMD	1 3	27	15	30 7	97	24	30 8	phd	Hw	37	
	RS1	5 0	27	15	36 8	97	24	42 5	phd		28	1230 T=29 3 DO=5 8 S=38 0
	RS2	1 8	27	15	15 4	97	24	47 4	phd	Hw	28	

phd = 0 014 square meters   Sf = Syringodium filiforme   Tt = Thalassia testudinum   Rm = Ruppia maritima
Ekman = 0 023 square meters   Hw = Halodule wrightii   He = Halophila engelmannii
Oar = 0 047 square meters

TABLE 2
Station Locations and Descriptions, Benthos Survey, May 1996
Lower Laguna Madre

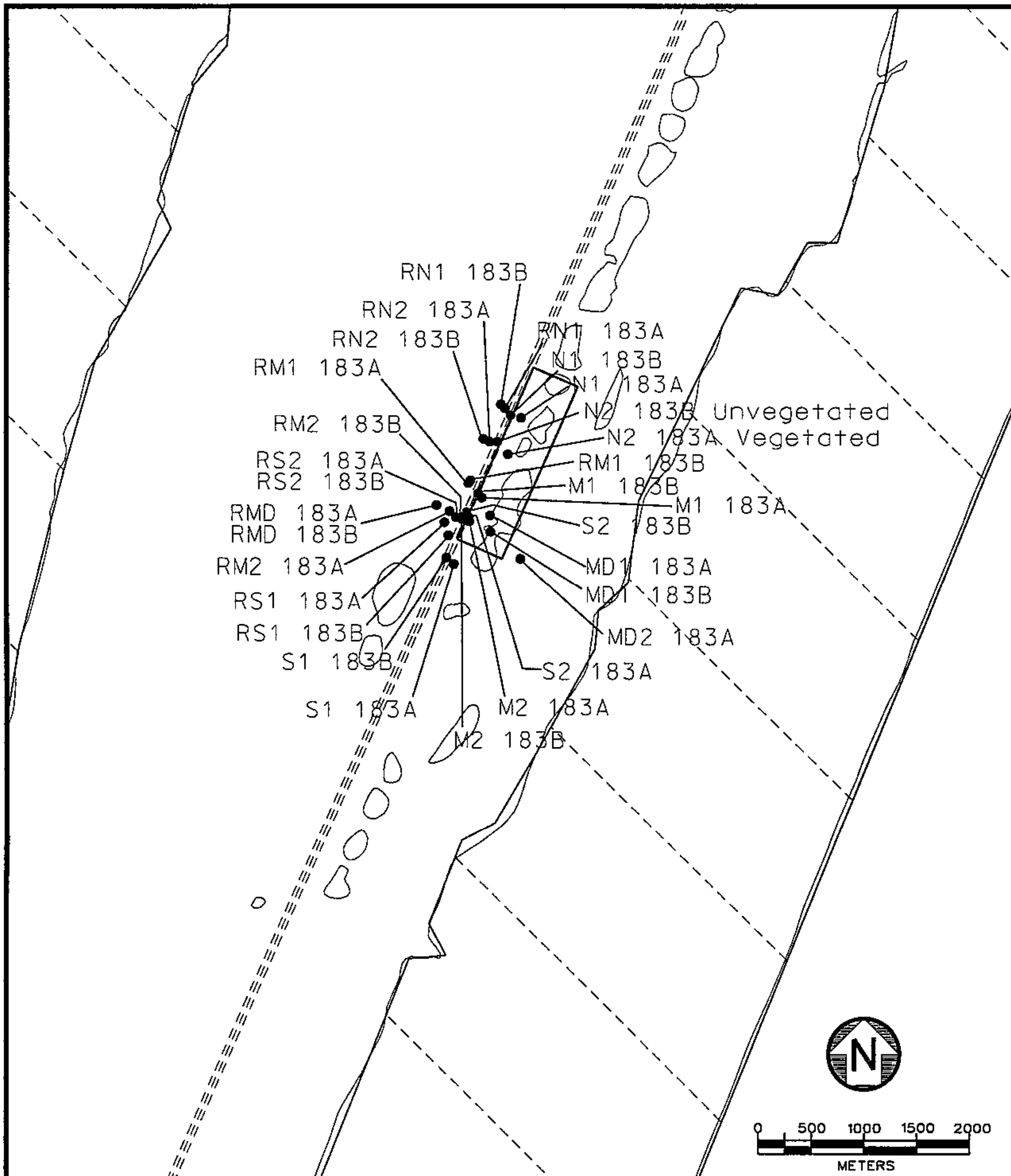
Placement Area	Station	Depth (feet)	North Degrees	North Minutes	North Seconds	West Degrees	West Minutes	West Seconds	Sampler	Seagrass	Secchi (cm)	Comments
214	N1	6 9	26	43	33 2	97	27	10 5	Ekman		19 0	Red 64 between N1 &RN1
	N2	7 3	26	43	24 4	97	27	3 9	Ekman		22 5	1100 hours muddy water
	M1	2 4	26	43	26 0	97	26	58 5	Ekman	Sf	16 0	
5/14/96	M2	6 4	26	43	1 8	97	26	55 4	Ekman		18 0	
	MD1	7 9	26	43	20 9	97	26	26 4	Ekman		18 5	
	MD2	7 4	26	42	59 9	97	26	27 6	Ekman		16 5	
	S1	6 5	26	42	49 1	97	26	47 0	Ekman		14 5	Hard bottom not much penetration with Ekman
	S2	6 1	26	42	35 4	97	26	45 1	Ekman		16 0	Red 70 between S2 &RS2 hard bottom starfish
	RN1	6 6	26	43	35 2	97	27	22 4	Ekman		25 0	Starfish
	RN2	6 5	26	43	25 8	97	27	25 9	Ekman		24 0	Starfish
	RM1	6 6	26	43	19 7	97	27	15 9	Ekman		27 0	
	RM2	8 0	26	43	3 4	97	27	14 3	Ekman		28 0	
	RMD	4 2	26	43	10 1	97	27	31 0	Ekman		22 0	
	RS1	9 0	26	42	47 3	97	27	9 4	Ekman		28 5	
	RS2	9 2	26	42	34 9	97	27	9 2	Ekman		31 0	Starfish brown shrimp
219	N1	9 0	26	35	45 7	97	24	26 2	Ekman		25 0	Red 128
	N2	8 1	26	35	34 8	97	24	21 8	Ekman		31 0	
	M1	8 5	26	35	29 5	97	24	22 4	Ekman		27 5	
5/15/96	M2	8 7	26	35	11 5	97	24	18 9	Ekman		24 5	Anaerobic
	MD1	8 3	26	35	24 8	97	24	9 1	Ekman		25 5	
	MD2	8 5	26	35	25 0	97	24	6 1	Ekman		26 0	
	S1	8 4	26	35	13 1	97	24	19 0	Ekman		29 0	Anaerobic
	S2	8 0	26	35	8 7	97	24	11 0	Ekman		30 5	Anaerobic
	RN1	6 1	26	35	45 5	97	24	47 0	Ekman		27 5	
	RN2	6 1	26	35	33 7	97	24	45 5	Ekman		21 0	Starfish
	RM1	8 3	26	35	29 3	97	24	37 8	Ekman		24 5	
	RM2	8 5	26	35	13 0	97	24	41 4	Ekman		25 5	Brittle Star
	RMD	7 5	26	35	21 3	97	24	47 5	Ekman		22 0	
	RS1	8 9	26	35	12 4	97	24	38 1	Ekman		23 0	
	RS2	8 4	26	35	4 8	97	24	39 7	Ekman		24 5	2 Brittle Stars off at 1050
221	N1	3 5	26	32	28 7	97	24	29 0	Ekman	Hw, Sf	18 0	Bouy 149
	N2	3 6	26	32	1 4	97	24	21 2	Ekman		21 0	Bouy 151
5/15/96	M1	3 1	26	31	37 7	97	24	9 6	Ekman	Sf	18 0	Bouy 155
	M2	2 2	26	31	11 3	97	23	58 3	Ekman	Hw	20 0	Bouy 157A
	MD1	1 0	26	31	11 4	97	24	12 6	Oar	Sf	ND	
	MD2	1 5	26	31	11 3	97	24	1 3	Oar		19 0	Approx 300 east of M2
	S1	1 9	26	30	20 1	97	23	35 8	Oar		22 0	Bouy 161A
	S2	2 0	26	30	6 3	97	23	29 1	Oar	Sf	18 0	Bouy 163
	RN1	5 6	26	32	26 0	97	24	9 0	Ekman		17 5	Bouy 149
	RN2	5 8	26	31	58 2	97	23	54 3	Ekman		17 0	Two partial grabs with Ekman Bouy 151
	RM1	4 2	26	31	36 4	97	23	46 4	Ekman		24 0	Bouy 155
	RM2	4 6	26	31	9 1	97	23	36 9	Ekman		21 0	Bouy 157A
	RMD	4 1	26	31	11 4	97	23	31 1	Ekman		20 0	Bouy 157A
	RS1	3 1	26	30	19 0	97	23	13 8	Ekman		21 0	Bouy 161A
	RS2	3 2	26	30	14 4	97	23	4 9	Oar	Hw, He	30 0	Bouy 163

TABLE 2 (Concluded)

Placement Area	Station	Depth (feet)	North Degrees	North Minutes	North Seconds	West Degrees	West Minutes	West Seconds	Sampler	Seagrass	Secchi (cm)	Comments
229	N1	2 1	26	17	57 5	97	17	41 1	Ekman	Hw	54 5	Green 31
	N2	2 3	26	17	53 8	97	17	38 4	Ekman	Hw, Sf	17 0	Green 33 algae
	M1	1 8	26	17	38 3	97	17	34 4	Ekman	Hw	34 0	
5/16/96	M2	0 8	26	17	19 2	97	17	30 7	Ekman	Hw	35 0	
	MD1	2 4	26	17	32 8	97	17	19 4	Ekman	Sf	63 0	Algae secchi on bottom
	MD2	2 1	26	17	20 8	97	17	13 3	Ekman		63 0	Sample taken in clear spot secchi on bottom
	S1	1 0	26	17	10 2	97	17	26 0	Ekman	Hw, Sf	33 0	
	S2	1 2	26	16	53 5	97	17	18 3	Ekman	Hw	30 0	Just east of Green 41
	RN1	2 0	26	17	54 9	97	17	56 6	Ekman	Sf	35 0	Green 31 algae
	RN2	2 0	26	17	46 5	97	17	54 0	Ekman	Hw	37 0	Green 33
	RM1	1 0	26	17	35 1	97	17	46 5	Ekman	Hw	25 0	
	RM2	1 4	26	17	17 3	97	17	34 5	Ekman	Hw	31 0	
	RMD	0 9	26	16	56 7	97	17	37 4	Ekman	Tt	28 0	Secchi on bottom
	RS1	1 2	26	17	10 8	97	17	31 0	Ekman	Hw, Sf	31 0	
	RS2	1 4	26	16	52 7	97	17	24 6	Ekman	Sf	34 0	Secchi on bottom
234	N1	4 6	26	9	49 1	97	14	45 6	Ekman		22 0	
	N2	3 2	26	9	41 7	97	14	48 6	Ekman		24 0	
	M1	4 9	26	9	26 9	97	14	34 1	Ekman		31 5	T=27 6 S=38 6 DO=6 0 avoiding fishermen
5/21/96	M2	3 3	26	8	59 6	97	14	22 8	Ekman	Hw, He	ND	avoiding fishermen
	MD1	5 4	26	9	6 5	97	14	41 0	Ekman		27 0	
	MD2	5 3	26	8	49 9	97	14	30 9	Ekman		37 0	
	S1	3 2	26	8	36 5	97	14	7 9	Ekman	Hw	73 0	
	S2	2 9	26	8	23 0	97	14	1 3	Ekman	Tt, Sf	55 0	
	RN1	5 5	26	9	55 1	97	14	31 7	Ekman		29 0	Brittle star T=27 2 DO=5 9 S=35 9 pH=8 2
	RN2	5 5	26	9	53 1	97	14	25 6	Ekman		45 0	
	RM1	5 0	26	9	21 5	97	14	9 0	Ekman		28 0	
	RM2	4 9	26	9	6 3	97	13	55 4	Ekman		34 0	
	RMD	4 9	26	9	17 9	97	13	56 1	Ekman		40 0	
	RS1	5 0	26	8	43 6	97	13	51 8	Ekman		29 0	
	RS2	5 6	26	8	31 2	97	13	42 3	Ekman		40 0	A couple of sprigs of Hw
236	N1	4 6	26	6	24 1	97	12	49 8	Ekman	Tt	39 0	
	N2	4 7	26	6	18 5	97	12	52 3	Ekman	Sf Tt	62 0	
	M1	4 3	26	6	7 4	97	12	42 7	Ekman	Tt	43 0	
5/21/96	M2	2 1	26	5	52 3	97	12	37 5	Ekman	Sf, Tt	40 5	
	MD1	3 6	26	5	56 9	97	12	50 6	Ekman	Sf, Tt	42 0	
	MD2	3 5	26	5	48 2	97	12	44 1	Ekman	Tt	32 0	
	S1	4 0	26	5	39 3	97	12	26 7	Ekman	Sf, Tt	38 0	
	S2	4 7	26	5	33 8	97	12	26 7	Ekman	Sf	33 5	
	RN1	4 7	26	6	31 1	97	12	36 8	Ekman	Sf	41 0	Algae T=25 4 DO=7 4 S=35 9 pH=8 1
	RN2	4 7	26	6	29 3	97	12	35 2	Ekman	Hw	51 0	
	RM1	4 4	26	6	10 8	97	12	26 5	Ekman	Sf, Tt	49 0	
	RM2	4 4	26	6	0 3	97	12	17 2	Ekman	Sf, Tt	48 0	
	RMD	4 0	26	6	8 3	97	12	7 9	Ekman	Tt	48 0	
	RS1	4 5	26	5	45 3	97	12	10 8	Ekman	Sf, Tt	43 0	
	RS2	4 4	26	5	41 5	97	12	6 1	Ekman	Hw	43 0	

phd = 0 014 square meters
Ekman = 0 023 square meters
Oar = 0 047 square meters

Tt = Thalassia testudinum
He = Halophila engelmannii



KEY

GIWW Gulf Intracoastal WaterWay

Land Area

Placement Area

Station

File t /projects/genv/corps/15650/bfig-4 dgn

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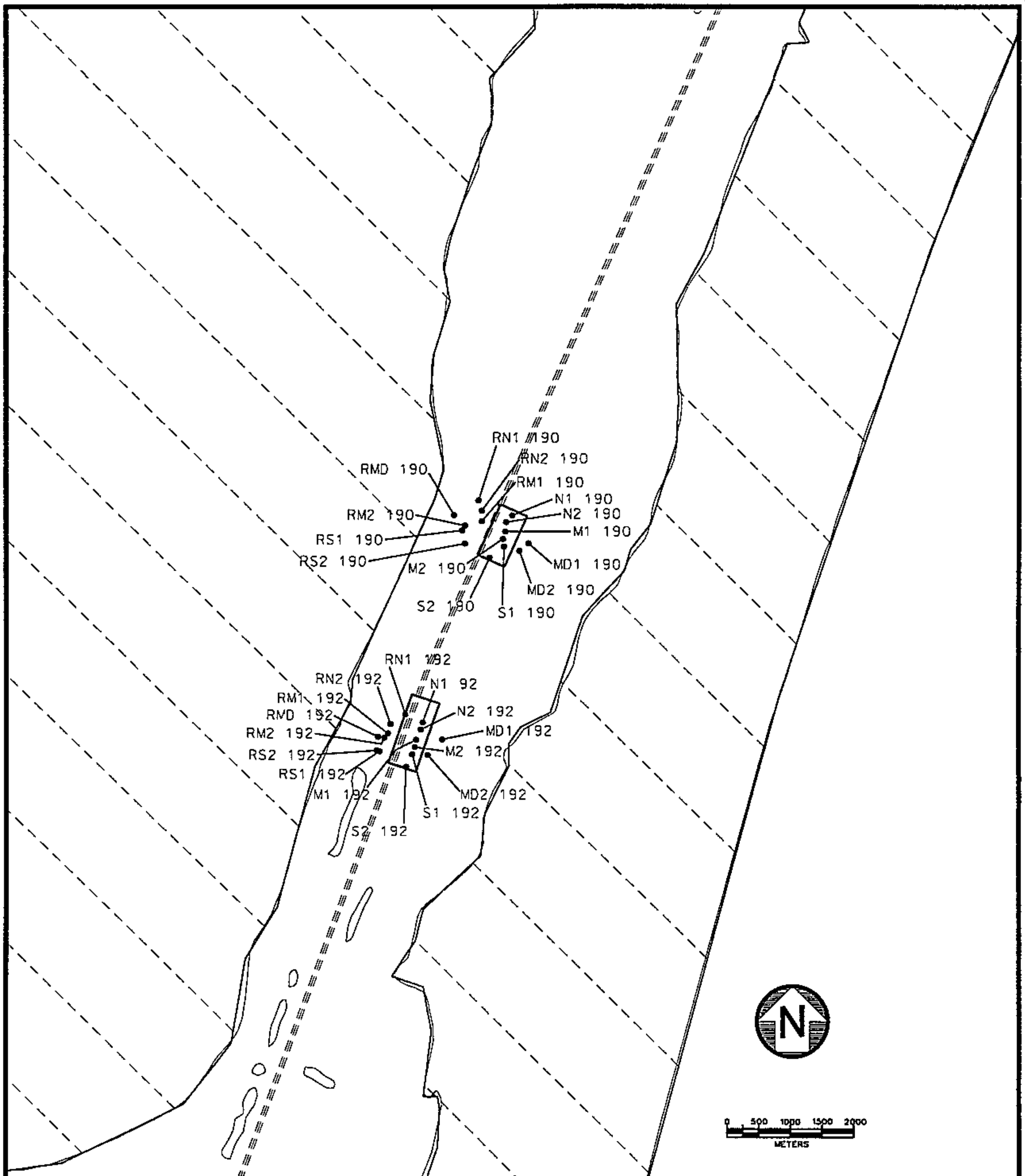
Figure 11

PA NO. 183
Fall 1996



KEY

GIWW	Gulf Intracoastal WaterWay
	Land Area
	Placement Area
•	Station

File L /projects/genv/corps/15650/bfig-5 dgn

Espey, Huston & Associates, Inc
Engineering & Environmental Consultants

Figure 12

PA NOS. 190 and 192
Fall 1996

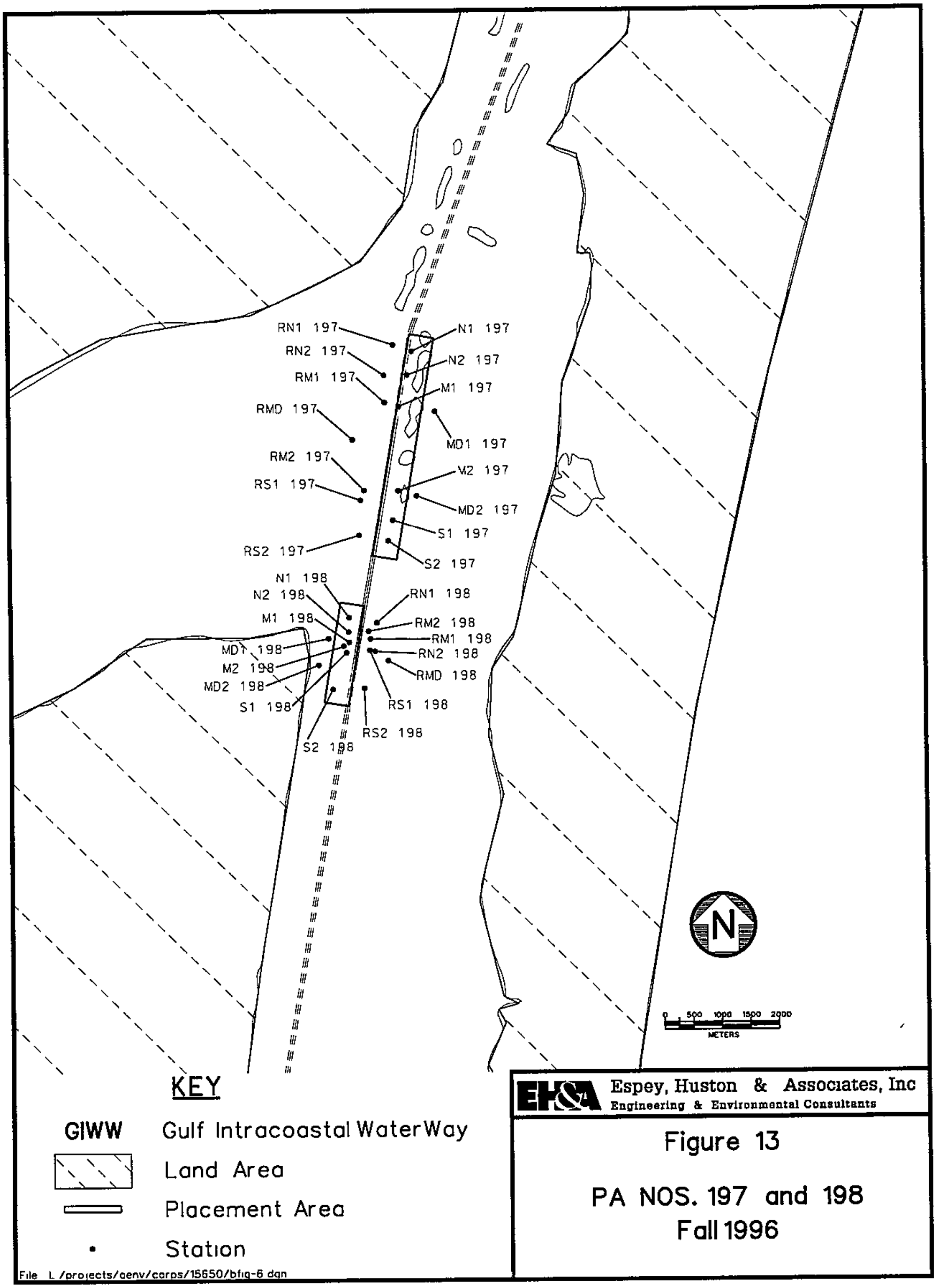


Figure 13

PA NOS. 197 and 198
Fall 1996

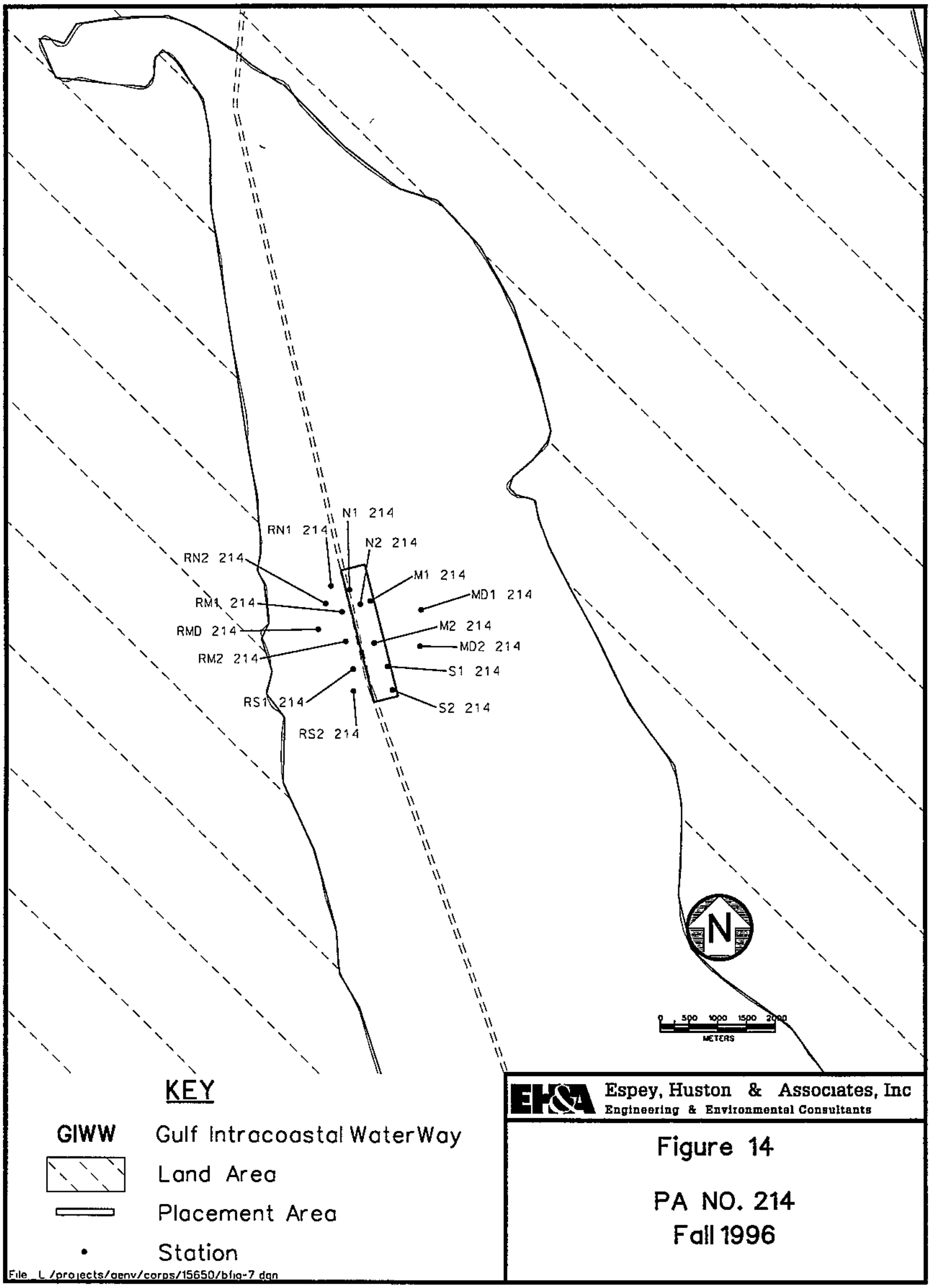
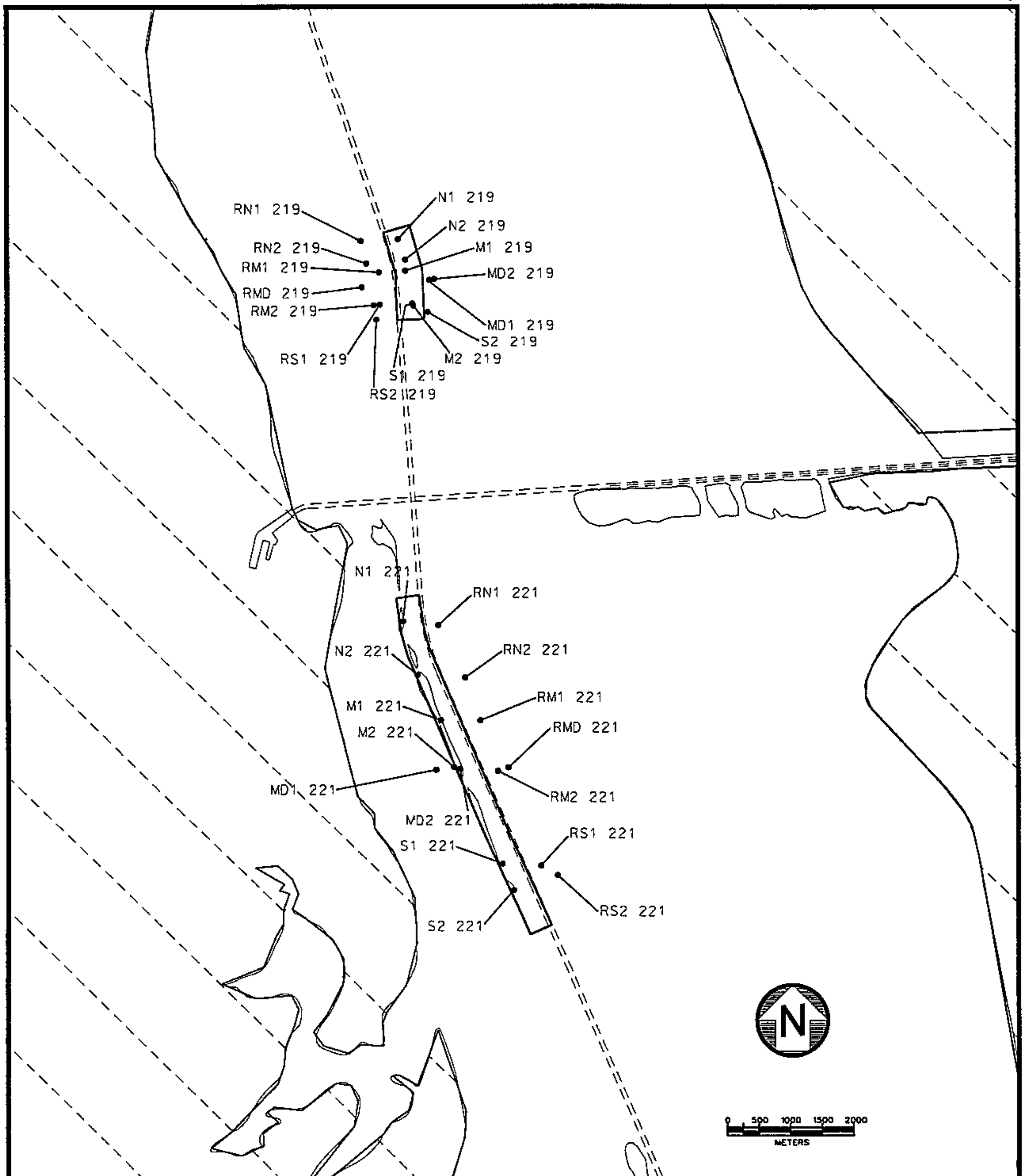


Figure 14

PA NO. 214
Fall 1996



KEY

GIWW Gulf Intracoastal WaterWay

Land Area

Placement Area

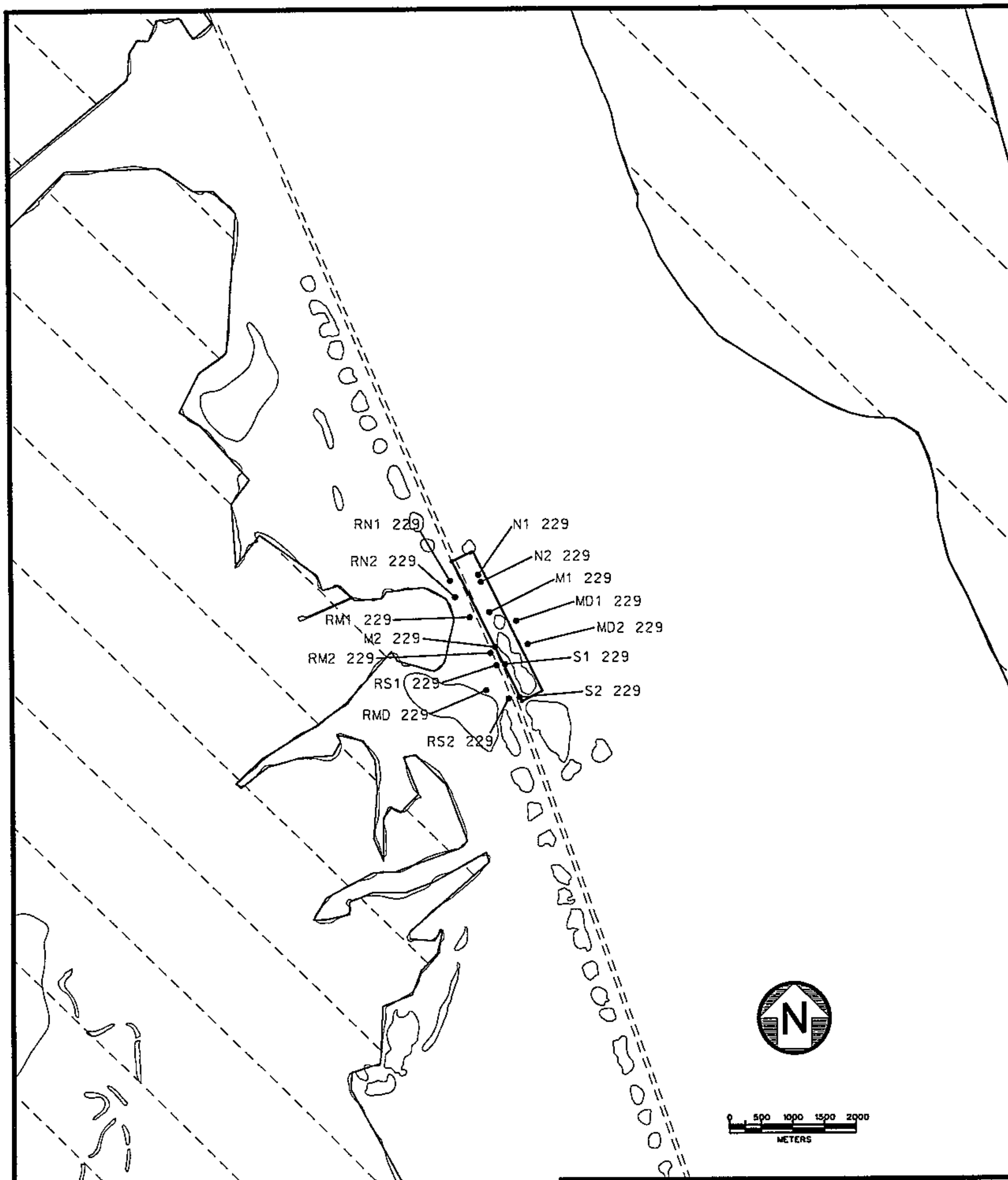
• Station

File L /projects/genv/corps/15650/bfig-8 dgn

Espey, Huston & Associates, Inc
Engineering & Environmental Consultants

Figure 15

PA NOS. 219 and 221
Fall 1996



KEY

GIWW Gulf Intracoastal WaterWay

Land Area

Placement Area

• Station

File L /projects/oenv/corps/15650/bfig-9 dgn

Espey, Huston & Associates, Inc.
Engineering & Environmental Consultants

Figure 16

PA NO. 229
Fall 1996

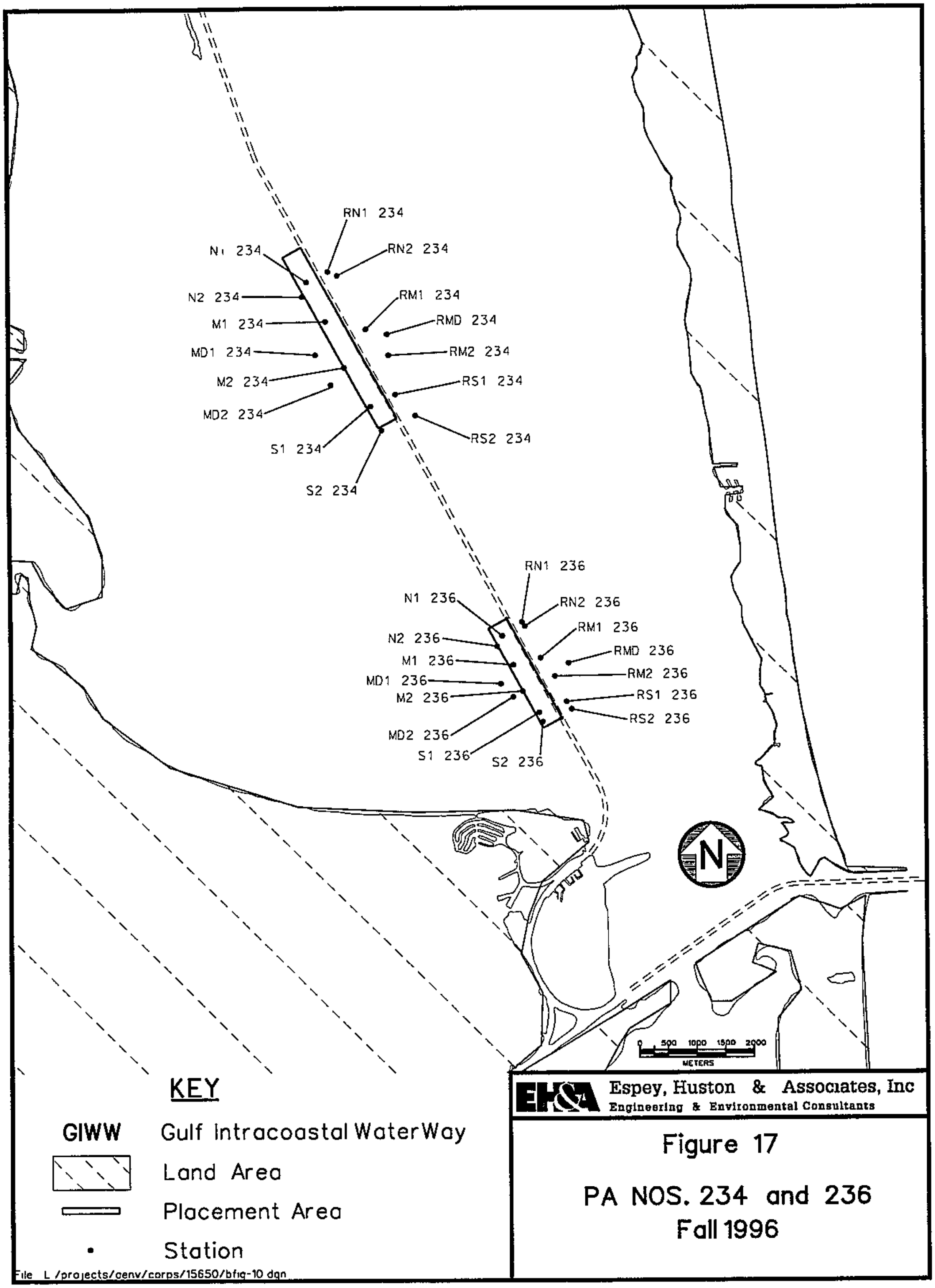


Figure 17

PA NOS. 234 and 236
Fall 1996

TABLE 3
Station Locations and Descriptions, Benthos Survey, September/October 1996
Upper Laguna Madre

Placement Area	Station	Depth (feet)	North Degrees	North Minutes	North Seconds	West Degrees	West Minutes	West Seconds	Sampler	Seagrass	Secchi (cm)	Comments
183A	N1	2 0	27	31	7 9	97	17	57 5	PHD	Hw	22	Anoxic
Vegetated	N2	1 8	27	30	56 6	97	18	2 4	PHD	Hw	22	Anoxic
	M1	2 7	27	30	43 3	97	18	11 8	PHD	Hw	18	
9/23/96	M2	2 7	27	30	36 0	97	18	16 3	PHD	Hw	21	Anoxic
	MD1		27	30	32 7	97	18	9 1	PHD		22	T=34 8 S>40 D O =9 9 pH=8 85
	MD2	2 3	27	30	24 2	97	17	58 9	PHD		22	
	S1	2 1	27	30	23 1	97	18	21 9	PHD	Hw	28	Anoxic
	S2	1 8	27	30	37 3	97	18	16 4	PHD	Hw	31	Anoxic
	RN1	5 1	27	31	11 0	97	18	3 0	PHD		21	Anoxic
	RN2	4 9	27	31	0 7	97	18	8 6	PHD		18 5	
	RM1	1 9	27	30	47 9	97	18	16 2	PHD	Hw	18	Anoxic
	RM2	2 9	27	30	39 3	97	18	22 9	PHD		21	
	RMD	2 8	27	30	41 3	97	18	27 3	PHD		18 5	
	RS1	2 8	27	30	35 9	97	18	24 8	PHD	Hw	20	
	RS2	1 5	27	30	37 4	97	18	20 8	PHD		19 5	
183B	N1	5 2	27	31	8 8	97	18	1 1	PHD		20	One small sprig of clovergrass
Unvegetated	N2	5 6	27	31	0 6	97	18	5 9	PHD		22 5	
	M1	4 9	27	30	44 6	97	18	13 0	PHD		20 5	
9/23/96	M2	5 3	27	30	36 9	97	18	18 9	PHD		18 5	
	MD1		27	30	32 7	97	18	9 1	PHD		22	T=34 8 D O =9 9 S=40 pH=8 85
	MD2	2 3	27	30	24 2	97	17	58 9	PHD		22	
	S1	4 8	27	30	25 1	97	18	24 3	PHD		21	Anoxic
	S2	4 5	27	30	38 9	97	18	17 1	PHD		25	
	RN1	2 7	27	31	12 2	97	18	4 3	PHD	Hw	22 5	Anoxic Near Green 97 and Red 98
	RN2	2 6	27	31	1 6	97	18	10 7	PHD	Hw	20 5	
	RM1	5 2	27	30	48 7	97	18	15 5	PHD		21	
	RM2	5 3	27	30	37 3	97	18	19 5	PHD		19 5	
	RMD	2 8	27	30	41 3	97	18	27 3	PHD		18 5	
	RS1	4 8	27	30	31 9	97	18	23 5	PHD		23	
	RS2	5 2	27	30	37 4	97	18	20 8	PHD		19 5	
190	N1	1 9	27	24	21 3	97	21	24 7	PHD	Hw	19 5	Anoxic
	N2	2 9	27	24	17 9	97	21	28 3	PHD	Hw	19 5	Anoxic
	M1	1 8	27	24	13 0	97	21	28 9	PHD	Hw	18 5	Anoxic
9/25/96	M2	0 9	27	24	9 2	97	21	30 4	PHD	Hw	15	Sampled 200 west of location
	MD1	4 8	27	24	6 6	97	21	15 7	PHD	He	18 5	
	MD2	5 1	27	24	2 8	97	21	21 1	PHD	Hw, He	19 5	
	S1	1 2	27	24	5 2	97	21	29 9	PHD	Hw	12	Anoxic
	S2	2 5	27	23	59 6	97	21	38 3	PHD	Hw	19	Anoxic
	RN1	4 5	27	24	29 4	97	21	43 9	PHD	Hw, He	18 5	
	RN2	4 0	27	24	24 0	97	21	42 2	PHD	Hw	19	Anoxic
	RM1	3 9	27	24	18 6	97	21	42 3	PHD	Hw, He	20	Anox T=31 1 D O =6 6 S=37 6 pH=8 6
	RM2	3 6	27	24	16 5	97	21	52 0	PHD	Hw	17	Anoxic
	RMD	3 3	27	24	22 1	97	21	58 1	PHD	Hw	19 5	Anoxic
	RS1	3 6	27	24	14 1	97	21	53 7	PHD	Hw	19	Anoxic
	RS2	3 4	27	24	7 2	97	21	52 2	PHD	Hw	18	

TABLE 3 (Concluded)

Placement Area	Station	Depth (feet)	North Degrees	North Minutes	North Seconds	West Degrees	West Minutes	West Seconds	Sampler	Seagrass	Secchi (cm)	Comments
192	N1	4 8	27	22	35 0	97	22	18 7	PHD	Hw	17	Anoxic mud some dead Halodule
	N2	4 4	27	22	31 3	97	22	19 9	PHD	Hw	23	Anoxic mud some dead Halodule
	M1	3 1	27	22	26 1	97	22	22 8	PHD	Hw	19 5	Anoxic
9/25/96	M2	1 9	27	22	22 3	97	22	23 7	PHD	Hw	24	Anoxic dense veg
	MD1	6 1	27	22	25 9	97	22	7 8	PHD		18 5	Anoxic
	MD2	6 0	27	22	17 9	97	22	16 3	PHD		19 5	
	S1	1 6	27	22	18 5	97	22	25 2	PHD	Hw	20 5	Anoxic
	S2	4 5	27	22	12 0	97	22	28 8	PHD		22	T=29 6 D O =4 2 S>40 pH=8 65
	RN1	8 4	27	22	39 4	97	22	28 6	PHD		18 5	
	RN2	3 7	27	22	34 6	97	22	37 2	PHD	Hw	20	Anoxic
	RM1	3 9	27	22	29 7	97	22	38 9	PHD	Hw	19	Anoxic some dead veg
	RM2	3.8	27	22	27 6	97	22	40 9	PHD	Hw	19 5	Anoxic
	RMD	3 8	27	22	28 1	97	22	44 6	PHD	Hw	20 5	Anoxic
	RS1	4 7	27	22	20 5	97	22	43 9	PHD	Hw, He	18	
	RS2	4 1	27	22	21 0	97	22	45 5	PHD	Hw	18	
197	N1	2 5	27	18	27 3	97	24	10 5	PHD	Hw	20	Between Red 210 and Green 209
	N2	2 0	27	18	13 7	97	24	13 8	PHD	Hw		Anoxic
	M1	3 6	27	17	55 8	97	24	19 7	PHD	Hw He	19 5	East of Green 13
9/24/96	M2	1 8	27	17	8 1	97	24	21 6	PHD	Hw	22 5	
	MD1	3 4	27	17	52 5	97	23	56 8	PHD	Hw, He	22	
	MD2	4 7	27	17	5 0	97	24	10 0	PHD		18	Anoxic
	S1	6 4	27	16	51 5	97	24	25.5	PHD		18 5	Anoxic
	S2	7 6	27	16	39 6	97	24	28 8	PHD		22	
	RN1	3 2	27	18	31 3	97	24	22 1	PHD		17	Anoxic
	RN2	2 8	27	18	13 9	97	24	28 3	PHD	Hw	17	T=31 3 D O=9 6 S>40 pH=8 7
	RM1	2 9	27	17	58 3	97	24	28 5	PHD	Hw	22	Anoxic
	RM2	6 1	27	17	8 8	97	24	43 1	PHD		23 5	Dead Halodule sparse live
	RMD	3 2	27	17	37 7	97	24	49 5	PHD	Hw, He	23	
	RS1	7 4	27	17	3 3	97	24	45 6	PHD		22	
	RS2	8 5	27	16	43 2	97	24	47 1	PHD		19	Anoxic
198	N1	7 9	27	15	56 1	97	24	55 1	PHD		19 5	
	N2	7 6	27	15	47 8	97	24	55 7	PHD		22	
	M1	7 9	27	15	41 9	97	24	55 5	PHD		23	
9/24/96	M2	4 9	27	15	39 8	97	24	59 0	PHD		24 5	Anoxic
	MD1	6 0	27	15	44 3	97	25	8 3	PHD		23	Avoiding shallow area
	MD2	5 4	27	15	29 3	97	25	15 0	PHD		25	
	S1	8 1	27	15	36 0	97	24	57 3	PHD		23 5	Anoxic Between red #12 and green #9
	S2	4 6	27	15	15 2	97	25	6 5	PHD		21	T=29 8 D O =5 7 S=39 9 pH=8 6
	RN1	7 9	27	15	52 7	97	24	37 5	PHD		23 5	Anoxic
	RN2	4 1	27	15	36 2	97	24	39 1	PHD		22	Dead Halodule
	RM1	6 4	27	15	43 5	97	24	41 8	PHD		25	Anoxic
	RM2	7 0	27	15	47 9	97	24	42 9	PHD		21	Anoxic
	RMD	1 6	27	15	30 7	97	24	30 9	PHD	Hw	24	
	RS1	5 3	27	15	37 0	97	24	42 5	PHD		22	Anoxic
	RS2	2 0	27	15	15 4	97	24	46 5	PHD		21	Dead Halodule

phd = 0 014 square meters; Sf = Syringodium filiforme; Tt = Thalassia testudinum
Ekman = 0 023 square meters; Hw = Halodule wrightii; He = Halophila engelmannii
Oar = 0 047 square meters

TABLE 4
Station Locations and Descriptions, Benthos Survey, September/October 1996
Lower Laguna Madre

Placement Area	Station	Depth (feet)	North Degrees	North Minutes	North Seconds	West Degrees	West Minutes	West Seconds	Sampler	Seagrass	Secchi (cm)	Comments
214	N1	6 9	26	43	32 7	97	27	10 9	PHD		20 5	Anoxic goopy
	N2	6 8	26	43	24 3	97	27	4 2	PHD		23 5	1537 hours T=24 6 S=30 5 DO=7 6 pH=8 55
	M1	2 5	26	43	26 0	97	26	57 8	PHD	Hw	24 5	Anoxic = Anox
9/30/96	M2	7 2	26	43	1 8	97	26	56 0	PHD		28 5	Anox
	MD1	8 0	26	43	20 2	97	26	26 3	PHD		26 5	Anox 1/8" hard crust over soft mud sand dollar
	MD2	7 5	26	42	59 4	97	26	27 5	PHD		24 0	Anox
	S1	6 3	26	42	48 3	97	26	48 0	PHD		25 0	Anox
	S2	5 5	26	42	34 9	97	26	45 2	PHD		27 0	Anox
	RN1	5 6	26	43	35 1	97	27	22 4	PHD		29 0	
	RN2	6 0	26	43	25 2	97	27	26 1	PHD		26 0	Brittle star Anox
	RM1	6 5	26	43	20 1	97	27	15 8	PHD		26 0	
	RM2	7 8	26	43	3 1	97	27	14 0	PHD		23 0	Anox
	RMD	5 9	26	43	10 5	97	27	31 0	PHD		25.0	Anox dense shell-hash
	RS1	8 8	26	42	47 3	97	27	9 6	PHD		27 0	Anox
	RS2	8 5	26	42	34 8	97	27	9 7	PHD		29 5	Anox
219	N1	9 3	26	35	45 9	97	24	26 6	Ekman		44 0	Anox too deep for PHD
	N2	8 5	26	35	35 3	97	24	22 6	PHD		43 0	Anox
	M1	8 9	26	35	29 6	97	24	22 7	PHD		63 0	Anox T=23 4 S=28 1 DO=6 3 pH=8 6
10/1/96	M2	8 4	26	35	11 4	97	24	18 7	PHD		54 5	Anox clayballs
	MD1	8 6	26	35	24 5	97	24	9 1	PHD		35 0	Anox brittle star
	MD2	8 8	26	35	24 9	97	24	6 5	PHD		47 0	Anox
	S1	8 9	26	35	12 6	97	24	19 4	PHD		59 0	Anox clayballs
	S2	7 0	26	35	8 0	97	24	10 7	PHD		55 0	Anox 0805 hours Air T = 23 Red 128
	RN1	6 5	26	35	45 4	97	24	47 8	PHD		43 0	Anox
	RN2	6 6	26	35	33 7	97	24	45 0	PHD		48 0	Anox
	RM1	8 6	26	35	29 0	97	24	37 9	PHD		45 0	Anox brittle star
	RM2	8 9	26	35	12 1	97	24	41 3	PHD		45 0	Anox
	RMD	7 7	26	35	21 6	97	24	47 9	PHD		40 0	Anox
	RS1	9 0	26	35	12 4	97	24	37 9	PHD		45 0	Anox
	RS2	8 9	26	35	4 7	97	24	40 1	PHD		45 0	Off at 1030

Placement Area	Station	Depth (feet)	North Degrees	North Minutes	North Seconds	West Degrees	West Minutes	West Seconds	Sampler	Seagrass	Secchi (cm)	Comments
221	N1	5 1	26	32	28 2	97	24	29 1	PHD	Hw	47 0	Anoxic seagrass dead but rooted brittle star
	N2	2 0	26	32	0 2	97	24	21 5	PHD	Hw	31 0	Anoxic = Anox
10/1/96	M1	4 2	26	31	36 5	97	24	8 9	PHD	Sf	51.0	Anox
	M2	2 8	26	31	11 0	97	23	58 6	PHD	Hw, Sf	36 0	Bouy 157A
	MD1	4 9	26	31	10 8	97	24	12 2	PHD	Hw	49 0	Seagrass dead but rooted
	MD2	2 8	26	31	12 1	97	24	2 1	PHD	Hw	47 0	Anox
	S1	1 2	26	30	20 8	97	23	35 8	PHD	Hw	35 6	Dense Hw Secchi on bottom
	S2	1 1	26	30	6 9	97	23	29 8	PHD	Hw	33 0	Bouy 163 Secchi on bottom
	RN1	6 0	26	32	25 8	97	24	9 1	PHD		31 0	Bouy 149
	RN2	6 9	26	31	58 3	97	23	54 5	PHD		37 0	1308 hours T=24 1 S=27 5 DO=6 4 pH=8 65
	RM1	4 8	26	31	35 8	97	23	46 4	PHD		38 0	Anox
	RM2	5 3	26	31	9 5	97	23	37 1	PHD		30 0	Bouy 157A
	RMD	4 9	26	31	11 2	97	23	31 0	PHD		36 0	Bouy 157A
	RS1	4 3	26	30	19 3	97	23	13 9	PHD		36 0	Anox
	RS2	3 6	26	30	14 1	97	23	4 6	PHD	Sf	45 0	Bouy 163 Wind picked up after RS2 may have affected Secchi depth of all other R Stations

TABLE 4 (Concluded)

Placement Area	Station	Depth (feet)	North Degrees	North Minutes	North Seconds	West Degrees	West Minutes	West Seconds	Sampler	Seagrass	Secchi (cm)	Comments
229	N1	2 0	26	17	57 7	97	17	40 2	PHD			Anox dense grass =A DG
	N2	2 0	26	17	53 9	97	17	38 8	PHD	Tt		A DG T=24 8 D O =5 8 S=27 3 pH=8 50
	M1	1 9	26	17	38 1	97	17	34 3	PHD	Hw	60 0	
10/2/96	M2	0 9	26	17	19 8	97	17	31 7	PHD	Hw		Algae
	MD1	2 2	26	17	33 1	97	17	19 1	PHD	Hw Tt	70 0	Algae
	MD2	2 5	26	17	20 8	97	17	13 0	PHD	Tt	78 0	Anox algae dense grass
	S1	1 3	26	17	10 8	97	17	26 4	PHD	Tt	42 0	Green 39 Anox
	S2	1 4	26	16	53 6	97	17	18 5	PHD	Hw	32 0	Anox
	RN1	2 3	26	17	54 9	97	17	56 3	PHD		70 0	Anox
	RN2	2 2	26	17	46 3	97	17	53 7	PHD	Tt	51 0	Anox algae
	RM1	1 2	26	17	35 7	97	17	45 7	PHD	Hw	35 0	Anox
	RM2	1 5	26	17	16 8	97	17	34 3	PHD	Hw	47 0	Anox
	RMD	1 3	26	16	57 7	97	17	37 5	PHD	Hw, Sf	25 0	
	RS1	1 4	26	17	10 4	97	17	31 2	PHD	Hw		Clams in benthos
	RS2	2 2	26	16	53 0	97	17	24 8	PHD		52 0	Anox

Placement Area	Station	Depth (feet)	North Degrees	North Minutes	North Seconds	West Degrees	West Minutes	West Seconds	Sampler	Seagrass	Secchi (cm)	Comments
234	N1	5 2	26	9	49 2	97	14	44 9	PHD		51 0	
	N2	3 6	26	9	40 8	97	14	48 1	PHD		56 0	
	M1	4 6	26	9	26 2	97	14	33 9	PHD		69 0	Anoxic clayey
10/2/96	M2	3 0	26	8	59 5	97	14	23 1	PHD	Hw, Sf	71 0	
	MD1	5 4	26	9	7 3	97	14	40 9	PHD		63 0	
	MD2	5 2	26	8	49 9	97	14	31 7	PHD		69 0	Fishermen in area
	S1	4 7	26	8	36 9	97	14	7 4	PHD	Tt Sf	64 0	Anoxic = Anox
	S2	3 3	26	8	23 0	97	14	0 9	PHD	Sf	55 0	Anox clayey
	RN1	5 4	26	9	54 8	97	14	31 4	PHD		62 0	Sandy
	RN2	5 4	26	9	52 4	97	14	25 6	PHD		69 0	Sandy
	RM1	4 8	26	9	21 2	97	14	8 8	PHD		59 0	Sandy T=26 9 Sal=31 4 D O = 6 4 pH=8 10
	RM2	4 7	26	9	6 0	97	13	55 2	PHD		61 0	Sandy
	RMD	4 7	26	9	18 0	97	13	55 7	PHD		49 0	Sandy
	RS1	4 7	26	8	43 4	97	13	51 7	PHD		59 0	Sandy brittle stsr in benthos
	RS2	4 5	26	8	31 1	97	13	39 7	PHD	Sf	60 0	
236	N1	5 1	26	6	23 9	97	12	49 6	PHD	Tt	56 0	Anox gelatinous
	N2	5 0	26	6	18 1	97	12	52 9	PHD	Tt, Sf	62 0	
	M1	4 8	26	6	7 2	97	12	43 1	PHD	Tt Sf	55 0	
10/3/96	M2	2 3	26	5	52 0	97	12	37 8	PHD	Tt, Sf	43 0	Clayey
	MD1	4 5	26	5	56 7	97	12	51 2	PHD	Tt	45 0	Anox
	MD2	3 8	26	5	48 9	97	12	43 7	PHD		59 0	Algae on surface of samples T=25 8 DO=5 1 S=31 2 pH=8 25
	S1	5 1	26	5	39 5	97	12	27 7	PHD	Tt	64 0	Gelatinous
	S2	5 4	26	5	34 2	97	12	25 6	PHD	Tt	57 0	
	RN1	5 4	26	6	31 5	97	12	37 1	PHD	Hw	62 0	
	RN2	5 4	26	6	29 1	97	12	35 4	PHD	Sf	66 0	Sandy and shelly
	RM1	4 6	26	6	10 8	97	12	25 9	PHD	Tt Sf	75 0	Course substrate
	RM2	4 6	26	6	0 1	97	12	17 3	PHD	Tt Sf	67 0	
	RMD	4 7	26	6	7 4	97	12	8 5	PHD	Sf	89 0	Shrimp eel in benthos
	RS1	4 9	26	5	45 3	97	12	10 3	PHD		61 0	Sandy
	RS2	5 3	26	5	41 0	97	12	7 3	PHD	Hw	62 0	Sandy

phd = 0 014 square meters
Ekman = 0 023 square meters
Oar = 0 047 square meters

Tt = Thalassia testudinum
He = Halophila engelmannii

3.3 BENTHIC SAMPLING

Each macroinfaunal sample was rinsed in the field using a 0 5-mm mesh sieve bucket Retained organisms and sediment were placed in plastic containers and preserved with a 10% formalin-seawater solution containing Rose Bengal stain.

Samples were inventoried by EH&A and shipped to BVA in Mobile, Alabama for taxonomic identification, enumeration, biomass measurement, and data interpretation.

3.4 LABORATORY ANALYTICAL TECHNIQUES

Benthic macroinfauna samples were inventoried and assigned a BVA laboratory number upon their transfer to the Taxonomy Laboratory Manager. Sample processing logs were prepared for each stage of sample analysis. The following methodology describes the processing of macroinfauna samples at the BVA laboratory.

3.4 1 Washing and Sorting

All samples received at the laboratory for benthic analysis were gently washed on a sieve with a mesh size of 0.5 millimeters (mm). This washing removed very fine sediment such as clay and silt, as well as formalin The material remaining on the sieve was washed back into the sample jar which was then filled with 70% isopropyl alcohol A 1% Rose Bengal solution was added to this preservative to stain soft tissues of organisms to allow for easier recognition when sorting animals from residue. In the sorting laboratory, samples were signed out of stock on the "Status Log " Each sample was first stirred with a water sprayer causing soft-bodied animals to float These animals were then poured onto a 0 5 mm sieve, washed, and transferred to a second beaker The portion of the sample composed of sediment and animals which did not float was rinsed through a 0 5 mm sieve and transferred to a beaker The sorter placed a portion of the sample into a small tray, added water, and placed the tray under a Wild M-5 research quality microscope. All macroinvertebrates were picked from the tray and placed in sample vials. This process was continued until the entire sample was completely processed

Animals were removed from the tray with fine forceps and placed into vials according to major taxon (i.e , Annelida, Echinodermata, Arthropoda, Mollusca, and Miscellaneous). An internal label written in India ink was placed in each vial. Each label contained the following information 1) phylum;

2) project name, 3) station and replicate number, 4) collection date, 5) sorting date; and 6) initials of the sorter. The vials containing the animals removed during sorting were stoppered and placed in a four-ounce jar This jar was labeled externally with the following information· 1) project name, 2) station and replicate number, 3) collection date, 4) sorting date, and 5) initials of the sorter.

After the sample was sorted, the residue was placed back into the sample jar, shelved for Quality Control (QC) purposes, and logged back into stock on the "Status Log."

3.4 2 Identification and Enumeration

Jars containing vials of sorted animals were transferred to the taxonomic laboratory, and a separate "Status Log'' was made for each identification and enumeration task (i.e., Annelida, Arthropoda, Mollusca, Echinodermata, and Miscellaneous) The taxonomist removed the sample from the shelf, signed that sample out of stock, and began identification and enumeration using a Wild M-5 stereo microscope and a Nikon Labophot compound microscope.

All taxa encountered were identified to species where possible Exceptions included Nematoda, Copepoda, and certain other organisms considered planktonic or meiofaunal. Nematodes were not identified or enumerated because they are considered meiofaunal. Non-harpacticoid copepods were not included in this benthic survey because they are incidentally caught during a benthic survey. Damaged specimens were identified to Lowest Practical Identification Level (LPIL) and only the heads were used for enumeration of individuals The LPIL acronym was also reserved for taxa which require very extensive processing to identify (e g , Phoronida and marine Oligochaeta, which require histological sectioning).

All data were entered on the "Taxonomic Data" sheet for each station and its replicates Taxonomists also enter pertinent comments indicating activities such as placing specimens in the voucher collection, or laboratory museum. Also, any information relating to identification, enumeration, or sample integrity was entered in the comments section.

Following completion of identification and enumeration, the sample was signed back into stock on the "Status Log." After all samples were completed (including verifications of identifications by both in-house and outside experts, and acceptance of all QC results by the Laboratory Manager), the samples and the voucher collections were archived at BVA. All "Taxonomic Data" sheets were transferred to the Data Manager for data entry, reduction, analysis, and interpretation

All resulting taxonomic data now reside in a FoxPro data management system at BVA. In addition to the preparation of the report, diskettes containing all data can be submitted

3.4.3 Wet Weight Biomass

Each replicate sample was analyzed for wet weight biomass of each major taxonomic group identified. Each of these groups of organisms was in a separate vial, preserved in 70% ethanol solution. The biomass technician then removed the organisms from the vial, placed them on a filter paper pad, gently blotted them with a paper towel, then immediately placed them in a tared dish and measured their weight in a Mettler Model AG-104 balance, to the nearest 0 01 mg Specimens required for the project reference (voucher) collection were returned to the appropriate species vial/jar in that collection

Once a sample was measured, this value was reported directly into a Quattro Pro spreadsheet file via a serial port connection between the AG-104 and the IBM-compatible computer. This spreadsheet application automatically saves the values and calculates the mean biomass of each major taxon (e g., Annelida, Crustacea, Mollusca, Echinodermata, and Miscellaneous) per station for all replicates.

3.5 DATA ANALYSIS

All data generated as a result of laboratory analysis of the macroinvertebrate samples were first coded on data sheets (i e , each species was given its own unique BVA taxonomic code). This BVA taxonomic code consists of a 10-digit number which represents the taxonomic hierarchy of the species For example, the code 3103010804 breaks down from left to right as follows: 31, Annelida (the phylum), 03, Oligochaeta (the class), 01, Naididae (the family), 08, *Nais* (the genus), and 04, *behningi* (the species) Enumeration data were entered for each taxon according to station and replicate These data were reduced and presented in a Data Summary Report for each station (Appendix A), which included a taxonomic listing and benthic assemblage parameters information. Archive data files of species identification and enumeration were prepared for each station in FoxPro® format on DOS compatible diskettes Also, archive species lists were prepared on diskettes which documented the 10-digit taxonomic code

The analytic strategies and methodologies utilized for this study were similar to other benthic assemblage characterization reports for surveys in the Gulf of Mexico Benthic assemblage analysis generally includes characterization of habitats and macrobenthic assemblages. Habitats are characterized primarily on the basis of physical environmental parameters, (e.g , water depth, sediment texture, etc) Macrobenthic characterization involves an evaluation of several biological assemblage structure parameters (e g., species composition and species diversity indices) during initial data reduction, followed by pattern and classification analysis for delineation of species assemblages. Since species are distributed along environmental gradients, there are generally no distinct boundaries between assemblages. However, the relationships between habitats and species assemblages reflect the interactions of physical and biological factors and express ecological trends

3.5.1 Community Structure

Prior to statistical analysis of the macroinfaunal data, all counts were standardized to the largest sample size to facilitate combining of different replicate sizes within stations. That is, numbers of individuals of each taxon are expressed as number per 0.047 m^2 for the Spring samples and per 0 014 m^2 for the Fall samples Various numerical indices were chosen for analysis and interpretation of the macrobenthic data base Selection was based primarily on the ability of the index to provide a meaningful summary of data, as well as the applicability of the index in the characterization of the benthic assemblage. Macrobenthic abundance was reported as the total number of individuals per station and as the total number of individuals per square meter (i e., density) Species richness was reported as both the total number of taxa represented in a given station collection and by Margalef's Index, D, (Margalef, 1958). This was estimated as $D = S\text{-}1/\log_e N$, where S is the number of taxa, and N is the number of individuals in the sample

Species diversity was estimated by the "Shannon-Weaver" Index (Margalef, 1956), according to the following formula:

$$H = - \sum_{i=1}^{s} p_i(\log_e p_i)$$

where, S - is the number of species in the sample,
I - is the i'th species in the sample, and

p_i - is the number of individuals of the i'th species divided by the total number of individuals of all species in the sample.

Species diversity within a given assemblage is dependent on both the number of taxa present (species richness) and the distribution of all individuals among those species (equitability or evenness) In order to quantify and compare the equitability in the fauna to the species diversity for a given area, Pielou's Index J' (Pielou, 1966) was calculated as $J' = H' / \log_e S$, where $\log_e S = H'$ max, or the maximum possible diversity, when all species are represented by the same number of individuals; thus, $J' = H' / H'$ max.

3.5 2 Macrobenthic Similarities

Numerical classification analysis (Boesch, 1977) was performed on the benthic macroinvertebrate data to examine within- and between- station differences by site and to compare benthic macroinvertebrate composition at each station Both normal and inverse classification analyses were used in this study Normal analysis (sometimes called Q-analysis) treats samples as individual observations, each being composed of a number of attributes (i e , the various species from a given sample) Normal analysis is instructive in helping to ascertain assemblage structure and to infer specific ecological conditions between sampling sites (stations) from the relative distributions of species. Inverse classification (termed R-analysis) is based on species as individuals, each of which is characterized by its relative abundance in the various samples This type of analysis is commonly used to identify species groupings with particular habitats or environmental conditions.

Classification analysis of both station collections (normal analysis) and species (inverse analysis) was performed using the Czekanowski quantitative index of faunal similarity (Field and MacFarlane, 1968). This index is computationally equivalent to the Bray-Curtis similarity measure (Bray and Curtis, 1957).

The value of the similarity index is 1 0 when the two samples are identical and 0 when no species are in common. Hierarchical clustering of similarity values is achieved using the group-average sorting strategy (Lance and Williams, 1967) and displayed in the form of dendrograms (cluster graphs).

Both similarity classification and cluster analysis were performed with the aid of the microcomputer package, "Community Analysis System 5 0" (Bloom, 1994), as modified for use in BVA's benthic data management program These analyses are hypothesis generating versus hypothesis testing Species used in these analyses were selected according to their percent abundance (generally, those taxa which comprised greater than 1% of the individuals collected at any given station during any given sampling period or species that comprised at least 0.1% of all infauna collected during a sampling period to decrease the effects of rarefaction) and percent frequency (those taxa which occur in 75% or greater of the station collections for a given study area) Total densities for each of the selected species at a given station collection were log-transformed [$x=\ln(x+1)$] for the analysis

The comparison of normal and inverse classifications greatly enhances the ecological interpretation of the results and is recommended by Boesch (1977) as a routine post-clustering analysis Normal-inverse relationships are best examined in a two-way coincidence table, which is simply the original data matrix rearranged to reflect station and species groups resulting from the classification and clustering analysis

3.5 3 Statistical Comparisons

For statistical comparison in Sections 4 2 1, 4.2 2, and 4.2 3, the following were used

Cochran's test (EPA/USACE, 1978) was used to determine the homogeneity or heterogeneity of the variances The calculated C value (C_{calc}) is the ratio of the largest variance (s^2_{max}) to the sum of all variances (Σs^2) or $C_{calc} = s^2_{max}/\Sigma s^2$. C_{calc} is compared to the 95%-confidence-level tabulated C value ($C_{0\,05(k\,v)}$), where k is the number of data sets being compared and v is one less than the number (n) of observations contributing to each variance If C_{calc} is less than $C_{0\,05(k\,v)}$, the variances are homogeneous, if C_{calc} is greater than $C_{0\,05(k\,v)}$, the variances are heterogeneous The advantage to Cochran's test as opposed to others is that zero variance is allowed

If the variances were homogeneous, the Student's t-test was performed utilizing 2(n-1) degrees of freedom to determine if the differences between the means was significant If the variances were heterogeneous, the t-test was still used, but with only (n-1) degrees of freedom used to determine the tabulated t-value

The Student's t-statistic is calculated by the following formula

$$t_{calc} = \frac{|\bar{X}_{control} - \bar{X}_{test}|}{[(s^2_{control}/n_{control}) + (s^2_{test}/n_{test})]^{1/2}}$$

where $\bar{X}$ is the mean survival, n is the number of replicates in the treatment, and s^2 is the variance associated with each respective mean.

If t_{calc} is less than the tabulated t-value at the 95% confidence level and for the appropriate degrees of freedom, the means are not statistically different If t_{calc} is greater than the tabulated t-value, the difference between the means is statistically significant

4.0 RESULTS AND DISCUSSION

In the following discussion of results, the data from the Spring sampling are discussed first, followed by a discussion of the Fall results. The discussion of the Fall results also includes a comparison with the Spring results where it is warranted For convenience, Figure 3 is repeated here to aid the reader when reference is made to PA stations (N1-52), near-PA stations (MD1-MD2), reference stations (RN1-R52), and near-reference stations (RMD)

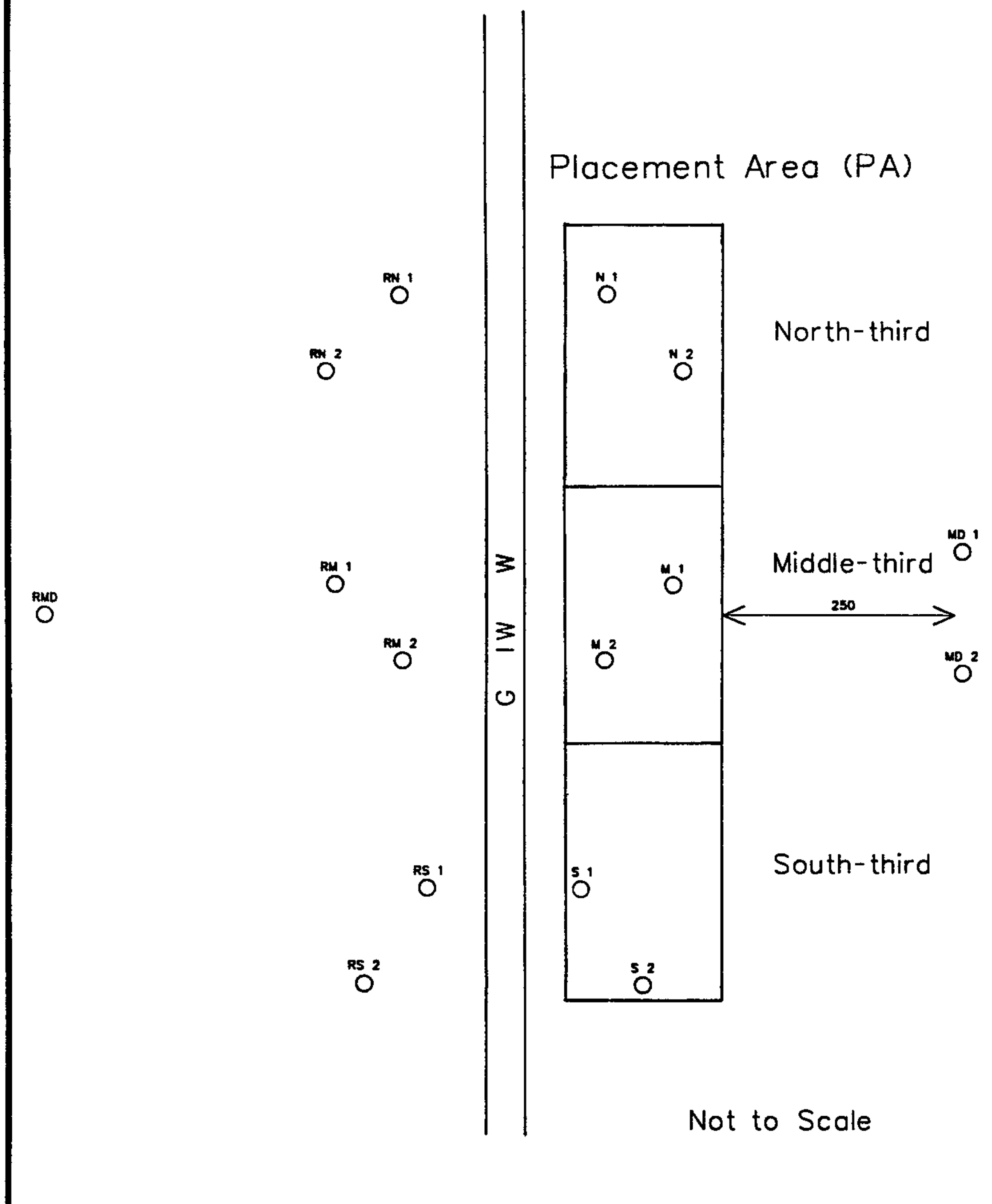
4.1 SEDIMENT TEXTURE

4.1 1 Spring 1996

Sediment texture data were furnished to EH&A by Anacon, Inc , and are summarized for each station in Table 5 No gravel (which includes shell hash) was reported at any station, although fine shell hash at a number of stations was seen in the field during sieving by field personnel Sediment classification identified four major categories sand, silty sand, silty-clayey sand; and sandy-clayey silt. These sediment types were generally associated with particular PAs For example, PAs 183A, 183B, and 229 were characterized mainly by silty sand PAs 190, 192, 214, and 221 contained predominantly sand substrates, and PAs 197, 198, 219, 234, and 236 were characterized by mixed sediments (from sand to loam to sandy-silty clay)

Sediments at stations within the dredged material placement areas (Replicates N1-S2) were similar in most cases to sediments at reference stations (Replicates RN1-RS2) However, relatively low percent sand was observed at stations within PAs 197, 234, and 236, indicating that past placement practices may have resulted in changes from predominantly sand habitats to mostly silt-clay habitats In contrast, the reference stations at PA 198 were considerably finer than the PA and near-PA stations.

Station depth is also provided in Table 5 These were actual water depths measured at the time of sampling Because of the amount of time spent at each station, the strong effect of wind on water height in the Laguna Madre, and the lag time between various portions of the Laguna Madre and any water height gauge, no attempt was made to reference measured water depths to mean low tide or any other convention



Espey, Huston & Associates, Inc.
Engineering & Environmental Consultants

Figure 3

Conceptual Stations

File L /projects/oenv/corps/15650/con-sta cgn

TABLE 5

Sediment texture at benthic stations sampled in the Laguna Madre, May, 1996
Sediment data represent average percent by dry weight

STATION	SITE/REPL.	DEPTH (FT)	% GRAVEL	% SAND	% SILT	% CLAY
1	183A (N1-S2)	2 3	0 0	60 4	31 5	8 1
3	183A (RN1-RS2)	2 8	0 0	72 7	24 6	2 6
5	183A (MD1-MD2)	1 5	0 0	70 8	20 0	9 3
7	183A (RMD)	2 5	0 0	66 3	30 6	3 1
8	183B (N1-S2)	4 9	0 0	93 6	4 7	1 8
10	183B (RN1-RS2)	4 8	0 0	84 1	13 2	2 7
12	183B (MD2)	1 6	0 0	79 9	15 6	4 5
13	198 (N1-S2)	6 3	0 0	47 5	13 6	38 7
14	198 (RN1-RS2)	4 9	0 0	20 9	36 1	42 9
15	198 (MD1-MD2)	5 2	0 0	62 1	10 9	27.1
16	198 (RMD)	1 3	0 0	38 2	22 7	39 1
17	197 (N1-S2)	3 2	0 0	52 3	25 9	21 8
18	197 (RN1-RS2)	4 7	0 0	72 9	6 7	20 4
19	197 (MD1-MD2)	3 9	0 0	53 5	23 0	23 6
20	197 (RMD)	3 0	0 0	85 4	6 1	8 5
21	192 (N1-S2)	2 7	0 0	87 4	5 1	7 5
22	192 (RN1-RS2)	3 3	0 0	88 5	4 9	6 6
23	192 (MD1-MD2)	2 7	0 0	93 8	1 8	4 5
24	192 (RMD)	3 6	0 0	88 5	1 8	9 7
25	190 (N1-S2)	1 9	0 0	82 5	8 5	9 1
26	190 (RN1-RS2)	3 7	0 0	87 1	9 3	3 6
27	190 (MD1-MD2)	4 7	0 0	82 6	15 5	2 0
28	190 (RMD)	3 2	0 0	90 2	1 3	8 5
29	214 (N1-S2)	5 9	0 0	89 4	6 0	4 6
30	214 (RN1-RS2)	7 7	0 0	94 5	3 1	2 4
31	214 (MD1-MD2)	6 3	0 0	98 9	0 4	0 7
32	214 (RMD)	4 2	0 0	95 7	0 0	4 3
33	219 (N1-S2)	8 5	0 0	43 2	19 3	37 2
34	219 (RN1-RS2)	7 7	0 0	75 9	10 3	13 8
35	219 (MD1-MD2)	8 4	0 0	71 6	13 4	15 1
36	219 (RMD)	7 5	0 0	71 9	13 8	14 3
37	221 (N1-S1)	2 7	0 0	83 9	10 7	5 4
39	221 (RN1-RS2)	4 4	0 0	81 8	11 3	6 9
41	221 (MD1-MD2)	1 3	0 0	70 3	19 5	10 3
42	221 (RMD)	4 1	0 0	97 9	1 1	1 0
43	229 (N1-S2)	1 5	0 0	37 2	43 3	19 6
44	229 (RN1-RS2)	1 5	0 0	49 4	35 4	15 2
45	229 (MD1-MD2)	2 3	0 0	65 6	24 0	10 5
46	229 (RMD)	0 9	0 0	38 9	45 3	15 8
47	234 (N1-S2)	3 7	0 0	47 5	23 5	29 1
48	234 (RN1-RS2)	5 3	0 0	91 0	4 3	4 7
49	234 (MD1-MD2)	3 1	0 0	59 2	20 8	20 1
50	234 (RMD)	4 9	0 0	96 8	0 9	2 3
51	236 (N1-S2)	4 1	0 0	28 7	44 6	26 7
52	236 (RN1-RS2)	4 5	0 0	60 5	22 9	16 7
53	236 (MD1-MD2)	4 4	0 0	31 6	51 9	16 4
54	236 (RMD)	4 0	0 0	60 1	17 7	22 2

4.1 2 Fall 1996

Unlike the spring survey, gravel (primarily shell hash) was reported at 14 of the 49 stations (Table 6) Sediment classification identified the same four major categories as were found in the Spring sand, silty sand; silty-clayey sand; and sandy-clayey silt. These sediment types were generally associated with particular PAs For example, sand and silty sand sediments were most prevalent in the upper Laguna Madre, except for PAs 197 and 198, while lower Laguna Madre PAs (i e , PA 219 and south, except for PA 221) were characterized by mixed sediments (typically, silty-clayey sand) Sediments in September - October, 1996 were generally similar to those sampled in May, 1996, except that the upper Laguna Madre stations contained slightly higher amounts of sand during the Fall survey. None of the upper Laguna PA sediments contained gravel (shell hash), all 14 stations where gravel was reported were in the lower Laguna Madre.

As during the Spring survey, sediments at stations within the dredged material placement areas (Replicates N1-S2) were similar in most cases to sediments at reference stations (Replicates RN1-RS2) In the Spring report, it was noted that relatively low percent sand was observed at stations within PAs 197, 234, and 236, indicating that past disposal practices may have resulted in some changes from predominantly sand habitats to mostly silt-clay habitats The Fall data show that this was only still true at PAs 234 and 236 At PA 234, the difference between N1-S2 and RN1-RS2 was not as great (57% vs 68% sand) in the Fall as it was in the Spring (48% vs 91% sand) For PA 236, the difference was still dramatic 29% vs 61%, Spring, 29% vs 62%, Fall Also in contrast to the Spring, PA 198 did not show the marked increase in sand from reference to PA and near-PA stations.

4.2 BENTHIC COMMUNITIES

4.2 1 Spring 1996

4 2 1 1 Faunal Composition, Abundance, and Community Structure

A total of 35,086 individuals representing 396 taxa was identified from 178 discrete samples When numbers of individuals per sample were standardized to the number per 0 047 m², the adjusted total number of individuals increased to 92,649 (Table 7) Polychaetes comprised the majority of individuals (43,978 or 47.5%), and the greatest number of taxa (162 or 40 9%) The most abundant species-level taxon collected was the polychaete *Prionospio heterobranchia* (7250 individuals or 7 8%) (Table 8). The

Table 6 Sediment texture at benthic stations in Laguna Madre, Texas, September - October, 1996

STATION (BVA)	SITE/REP	DEPTH (FT)	% GRAVEL	% SAND	% SILT	% CLAY
1	183A (N1-S2)	2 2	0 0	85 6	9 0	5 4
2	183A (RN1-RS2)	3 2	0 0	93 2	3 4	3 5
3	183A (MD1-MD2)	2 3	0 0	82 6	7 5	10 0
4	183A (RMD)	2 8	0 0	90 6	4 9	4 5
5	183B (N1-S2)	5 1	0 0	95 6	3.3	1 1
6A	183B (RN1-RS2)	4 3	0 0	96 8	1 9	1 3
6B	183B (MD1-MD2)	2 3	0 0	82 6	7 5	10 0
6C	183B (RMD)	2 8	0.0	90.6	4 9	4 5
7	190 (N1-S2)	1 9	0.0	76 8	12 4	10 8
8	190 (RN1-RS2)	3.8	0 0	69 5	17 9	12 7
9	190 (MD1-MD2)	5.0	0 0	81 2	10 4	8 4
10	190 (RMD)	3 3	0 0	83 3	1 4	15 3
11	192 (N1-S2)	3 4	0 0	79 1	10 5	10 4
12	192 (RN1-RS2)	4.8	0 0	77 1	14 5	8 4
13	192 (MD1-MD2)	6 1	0 0	75 1	16 4	8 5
14	192 (RMD)	3 8	0 0	85 5	7.8	6 7
15	197 (N1-S2)	4 0	0 0	73 1	12 3	14 6
16	197 (RN1-RS2)	5 2	0 0	69 8	10 1	20 1
17	197 (MD1-MD2)	4 1	0 0	38 4	33 8	27 9
18	197 (RMD)	3 2	0 0	75.3	11 8	12.9
19	198 (N1-S2)	6 8	0 0	68 5	11 1	20.5
20	198 (RN1-RS2)	5.5	0 0	40 0	29 0	31.0
21	198 (MD1-MD2)	5 7	0 0	43 4	27 1	29 6
22	198 (RMD)	1 6	0 0	97 9	0 8	1 3
23	214 (N1-S2)	5 9	0 8	84 0	9.7	5 6
24	214 (RN1-RS2)	7 2	0 3	87 5	9.7	2 6
25	214 (MD1-MD2)	7 8	2 5	69 0	20 9	7 7
26	214 (RMD)	5 9	0 3	88 8	8.3	2 6
27	219 (N1-S2)	8 5	0 5	71 1	8 4	20 0
29	219 (RN1-RS2)	8 1	0 3	73 6	16 9	9 2
30	219 (MD1-MD2)	8 7	0 5	54 1	16 3	29 1
31	219 (RMD)	7 7	0 0	82 1	3 2	14 7
32	221 (N1-S2)	2 7	0 8	80 5	10 6	8 3
33	221 (RN1-RS2)	5 2	0 3	87 0	3 7	9 1
34	221 (MD1-MD2)	3 9	0 0	49 3	19 5	31 3
35	221 (RMD)	4 9	0 0	95 4	0 0	4 6
36	229 (N1-S2)	1 6	0 2	46 2	31 4	22 2
37	229 (RN1-RS2)	1 8	0 0	40 7	43 0	16 4
38	229 (MD1-MD2)	2 4	0 0	56 2	31 7	12 2
39	229 (RMD)	1 3	0 0	19 2	65 0	15 8
40	234 (N1-S2)	4 1	0 4	57 0	19 3	23 3
41	234 (RN1-RS2)	4 9	0 6	68 1	17 6	13 8
42	234 (MD1-MD2),	5 3	0 2	68 0	20 9	11 0
43	234 (RMD)	4 7	0 4	89 2	6 8	3 6
44	236 (N1-S2)	4 6	0 0	28 9	41 6	29 6
45	236 (RN1-RS2)	5 0	0 0	61 6	19 3	19 1
46	236 (MD1-MD2)	4 2	0 0	22 8	67 7	9 6
47	236 (RMD)	4 7	0 0	56 4	25 6	18 0

TABLE 7

Taxonomic listing and abundance of major Phyla from Laguna Madre, Texas survey, May, 1996

Taxa	No. Individuals	% Total	No. Taxa	% Total
Polychaeta	43978	47 5	162	40.9
Oligochaeta	12387	13 4	1	0.3
Amphipoda	21991	23 7	53	13.3
Other Crustacea	4763	5 1	59	14.9
Pelecypoda	4293	4 6	49	12.4
Gastropoda	2477	2 7	42	10 6
Other Mollusca	603	0.7	6	1.5
Echinodermata	104	0.1	13	3.3
Other Phyla	2053	2.2	11	2.8
Total	92649	100 0	396	100 0

Table 8. Taxonomic listing and abundance of numerically dominant taxa from Laguna Madre, Texas survey, May, 1996

SPECIES		NO. INDIVIDUALS	% TOTAL	CUMULATIVE %	STATION OCCURRENCE	% STATION OCCURRENCE
Oligochaeta (LPIL)	(O)	12387	13 4	13 4	36	76 6
Prionospio heterobranchia	(P)	7250	7 8	21 2	34	72 3
Ampelisca abdita	(C)	5729	6 2	27 4	40	85 1
Asychis elongatus	(P)	4557	4 9	32 3	35	74 5
Capitella capitata	(P)	4415	4 8	37 1	39	83 0
Exogone dispar	(P)	4165	4 5	41 6	40	85 1
Mediomastus (LPIL)	(P)	4053	4 4	45 9	39	83 0
Elasmopus levis	(C)	3566	3 8	49 8	28	59 6
Cerapus tubularis	(C)	3225	3 5	53 3	39	83 0
Melinna maculata	(P)	2787	3 0	56 3	42	89 4
Heteromastus filiformis	(P)	2127	2 3	58 6	17	36 2
Streblospio benedicti	(P)	1980	2 1	60 7	23	48 9
Xenanthura brevitelson	(C)	1873	2 0	62 7	20	42 6
Grandidierella bonnieroides	(C)	1630	1 8	64 5	26	55 3
Erichthonius brasiliensis	(C)	1610	1 7	66 2	31	66 0
Chone (LPIL)	(P)	1572	1 7	67 9	32	68 1
Bittium varium	(M)	999	1 1	69 0	22	46 8
Rhynchocoela (LPIL)	(R)	966	1 0	70 0	41	87 2
Syllis broomensis	(P)	946	1 0	71 1	26	55 3
Naineris dendritica	(P)	944	1 0	72 1	12	25 5
Mulinia lateralis	(M)	935	1 0	73 1	30	63 8
Anomalocardia auberiana	(M)	756	0 8	73 9	27	57 4
Polydora cornuta	(P)	734	0 8	74 7	23	48 9
Hargeria rapax	(C)	732	0 8	75 5	18	38 3
Actiniaria (LPIL)	(A)	714	0 8	76 3	33	70 2
Deutella incerta	(C)	694	0 7	77 0	21	44 7
Paracaprella tenuis	(C)	653	0 7	77 7	25	53 2
Cymadusa compta	(C)	567	0 6	78 3	12	25 5
Crepidula maculosa	(M)	546	0 6	78 9	16	34 0
Erichsonella attenuata	(C)	514	0 6	79 5	21	44 7
Grubeosyllis clavata	(P)	489	0 5	80 0	28	59 6
Diopatra cuprea	(P)	459	0 5	80 5	30	63 8
Corophium sp 1	(C)	430	0 5	81 0	10	21 3
Paraprionospio pinnata	(P)	428	0 5	81 4	12	25 5
Lembos (LPIL)	(C)	405	0 4	81 9	14	29 8
Amygdalum papyria	(M)	376	0 4	82 3	24	51 1
Mitrella lunata	(M)	333	0 4	82 6	12	25 5
Eusarsiella zostericola	(C)	331	0 4	83 0	21	44 7
Ceratonereis irritabilis	(P)	315	0 3	83 3	21	44 7
Monticellina dorsobranchialis	(P)	308	0 3	83 6	8	17 0
Batea catharinensis	(C)	306	0 3	84 0	13	27 7
Spirorbis spirillum	(P)	299	0 3	84 3	9	19 1
Nuculana acuta	(M)	296	0 3	84 6	7	14 9
Corophium louisianum	(C)	292	0 3	84 9	5	10 6
Polydora socialis	(P)	282	0 3	85 2	12	25 5
Caecum pulchellum	(M)	249	0 3	85 5	14	29 8
Cyclaspis varians	(C)	242	0 3	85 8	13	27 7
Leitoscoloplos (LPIL)	(P)	231	0 2	86 0	17	36 2
Melita (LPIL)	(C)	208	0 2	86 2	4	8 5
Cirratulidae (LPIL)	(P)	182	0 2	86 4	8	17 0
Nereidae (LPIL)	(P)	178	0 2	86 6	16	34 0
Microprotopus raneyi	(C)	174	0 2	86 8	12	25 5
Anadara transversa	(M)	172	0 2	87 0	3	6 4
Glycinde solitaria	(P)	168	0 2	87 2	21	44 7
Listriella barnardi	(C)	168	0 2	87 4	17	36 2
Phascolion strombi	(S)	167	0 2	87 5	14	29 8
Tellina texana	(M)	155	0 2	87 7	20	42 6
Cerapus benthophilus	(C)	147	0 2	87 9	8	17 0
Glycera americana	(P)	139	0 2	88 0	17	36 2
Xanthidae (LPIL)	(C)	138	0 1	88 2	13	27 7
Anachis semiplicata	(M)	138	0 1	88 3	10	21 3

(C) =Crustacea (M) = Mollusca, (P) =Polychaeta, (R) = Rhynchocoela (O) = Oligochaeta, (A) = Actiniaria, (S) = Sipuncula second most abundant species was the amphipod *Ampelisca abdita* which was represented by 5729 individuals (6.2%) Oligochaeta (LPIL) comprised 13.4% of all individuals, but probably included more than one species. The taxon with the highest frequency occurrence was the polychaete, *Melinna maculata,* which was present at 42 of the 47 stations (See Appendix A for a listing of taxa)

Amphipod crustaceans were the second most abundant group with respect to individuals (21,991 or 23.7%), while all crustacea (including amphipods) represented the second-greatest number of taxa (112 or 28.2%)

Mollusks (including pelecypods and gastropods) contributed the third highest numbers of individuals (7373 or 8.0%), and 97 taxa (24 4%). *Bittium varium*, an opportunistic gastropod, was the most abundant mollusk, but only ranked 17th in individual abundance (999 or 1 1%)

Other phyla (Cnidaria, Platyhelminthes, Echinodermata, Hemichordata, Urochordata, Phoronida, Rhynchocoela, Sipuncula) comprised 2 3% of the individuals and 6.1% of the taxa during the May, 1996 survey. The most abundant such taxon was Rhynchocoela (LPIL), which was represented by 966 individuals (1 0%).

Community statistics by station are summarized in Table 9, and reflect a high degree of dissimilarity between sites, but moderate similarity between stations in the various sites Taxon abundance varied from 18 (PAs 190 and 214) to 165 (PA 234), and averaged 54 9 taxa for the 47 stations. The highest mean density (number of individuals/m²) was observed at PA 198 (N1-S2), with 32,080 individuals/m². The lowest mean density was found at PA 197 (RN1-RS2) with 560 individuals/m² PAs 183A and 229 had the highest individual abundances, while lowest abundances were found at PAs 214 and 219 Comparison of stations within the PAs with reference stations indicated that reference stations had much lower densities (and lower numbers of species) at PAs 198, 214, 221, 229, and 234 Using the Student's t-test (α = 0 05), the densities at the PAs were only significantly greater than at the reference stations at PAs 198, 229, and 234 while the differences in number of species was not significantly different except at PA 198 The mean density and number of taxa at the reference stations at PA 192 were not significantly greater than at the PA stations

PA 234 (N1-S2) was shown to have the highest H' value at 3.99, while the lowest diversity was measured at PA 198 (RN1-RS2) with an H' of 1.80. The highest diversity was due to a speciose and even polychaete, crustacean and molluscan assemblage, while the lowest diversity was due mainly to the

Table 9 Summary of benthic community parameters for Laguna Madre, Texas study transects, May 1996

	STATION NUMBER	TOTAL # TAXA	MEAN TAX /REP	TOTAL # INDIVID	MEAN DENSITY	STD DEV	H'	J'	D
1	183A (N1-S2)	66	26 9	4114	13713	8361	2 77	0 66	7 81
3	183A (RN1-RS2)	74	31 8	4892	16307	7601	2 92	0 68	8 59
5	183A (MD1-MD2)	47	36	2022	20220	6364	3 06	0 79	6 04
7	183A (RMD)	39	39	668	13360	0	2 99	0 82	5 84
8	183B (N1-S2)	49	24 8	3382	11273	5688	2 53	0 65	5 91
10	183B (RN1-RS2)	48	21 8	2618	8727	5932	2 61	0 67	5 97
12	183B (MD2)	32	32	1604	32080	0	2 18	0 63	4 20
13	198 (N1-S2)	46	17 2	2556	8520	10093	2 81	0 73	5 74
14	198 (RN1-RS2)	24	4 7	1144	3813	9184	1 8	0 57	3 27
15	198 (MD1-MD2)	30	18	968	9680	10409	2 18	0 64	4 22
16	198 (RMD)	20	20	700	14000	0	2 3	0 77	2 90
17	197 (N1-S2)	43	13 3	2608	8693	6539	2 74	0 73	5 34
18	197 (RN1-RS2)	36	13	2812	9373	7519	2 49	0 69	4 41
19	197 (MD1-MD2)	28	15 5	1088	10880	11653	2 18	0 65	3 86
20	197 (RMD)	26	26	456	9120	0	2 49	0 76	4 08
21	192 (N1-S2)	40	15 8	3380	11267	10549	1 97	0 53	4 80
22	192 (RN1-RS2)	50	21 7	5524	18413	7670	1 96	0 50	5 69
23	192 (MD1-MD2)	24	18	656	6560	113	2 16	0 68	3 55
24	192 (RMD)	23	23	352	7040	0	2 55	0 81	3 75
25	190 (N1-S2)	58	24	5148	17160	9061	2 52	0 62	6 67
26	190 (RN1-RS2)	61	24 3	5552	18507	12889	2 99	0 73	6 96
27	190 (MD1-MD2)	26	16 5	668	6680	3790	2 68	0 82	3 84
28	190 (RMD)	18	18	424	8480	0	1 95	0 67	2 81
29	214 (N1-S2)	80	29 7	1948	6493	3613	3 3	0 75	10 43
30	214 (RN1-RS2)	67	24 5	1046	3487	2476	3 21	0 76	9 49
31	214 (MD1-MD2)	38	24 5	292	2920	1131	3 12	0 86	6 52
32	214 (RMD)	18	18	78	1560	0	2 69	0 93	3 90
33	219 (N1-S2)	45	19 5	962	3207	1725	2 78	0 73	6 41
34	219 (RN1-RS2)	61	21 7	1294	4313	1910	2 78	0 68	8 37
35	219 (MD1-MD2)	31	20 5	380	4130	1527	2 55	0 74	5 05
36	219 (RMD)	35	35	212	4240	0	2 58	0 73	6 35
37	221 (N1-S1)	90	33 4	2219	8876	10042	3 38	0 75	11 55
39	221 (RN1-RS2)	80	24 8	998	2075	3327	3 22	0 73	11 44
41	221 (MD1-MD2)	57	38 5	701	7010	778	2 85	0 70	8 55
42	221 (RMD)	21	12 5	176	1760	962	2 26	0 74	3 87
43	229 (N1-S2)	102	44 7	8492	28307	9892	3 07	0 66	11 16
44	229 (RN1-RS2)	100	41 5	4392	14640	7200	3 24	0 70	11 80
45	229 (MD1-MD2)	68	48 5	2214	22140	2008	3 01	0 71	8 70
46	229 (RMD)	28	28	266	5320	0	2 68	0 80	4 84
47	234 (N1-S2)	165	53 3	4270	14233	11452	3 99	0 78	19 62
48	234 (RN1-RS2)	123	41	1370	4567	894	3 71	0 77	16 89
49	234 (MD1-MD2)	79	50	802	8020	3649	3 31	0 76	11 66
50	234 (RMD)	30	30	142	2840	0	2 81	0 83	5 85
51	236 (N1-S2)	125	43	2720	9066	4246	3 65	0 76	15 68
52	236 (RN1-RS2)	161	51 7	2968	9893	6134	3 85	0 76	20 01
53	236 (MD1-MD2)	46	27	686	6860	6025	3 2	0 84	6 89
54	236 (RMD)	24	24	92	1840	0	2 98	0 94	5 09

dominance of the amphipod *Cerapus tubularis*, and low species abundance Other stations with low diversity included PA 190 (RMD), PA 192 (N1-S2), and PA 192 (RN1-RS2) Diversity at stations in any given placement area and its reference stations were not notably different

Species evenness, J', reflected effects of the numerical dominance of opportunistic species stations listed above as having lower diversity due to higher proportions of a few taxa also had relatively low values of J'. For example, lowest J' (0.50) was observed at PA 192 (RN1-RS2), which had a diversity of 1.96. A J' value of 0.57 at PA 198 (RN1-RS2) was attributed to very high proportions of *C. tubularis* The highest J' values (0 93 and 0 94) occurred at stations where few species and few individuals were found.

Species richness, D, varied from 2 81 (PA 190, RMD) to 20.01 (PA 236, RN1-RS2), and corresponded closely to the number of taxa present. Overall, species richness values indicated the presence of a high-quality and uniformly distributed estuarine infaunal community

Mean infaunal standing crop (wet weight biomass) varied significantly from 0 182 gm/ 0 05 m^2 at PA 190 (RMD) to 6.634 gm/0.05 m^2 at PA 192 (RMD) (Table 10). The highest value was attributed to an unusual weight of echinoderms

4 2 1.2 Numerical Classification Analysis

Normal (station) and inverse (species) classification analyses were performed on the May, 1996 data set and displayed as dendrograms (figures 18 and 19) Count data for the 61 species selected for analysis (24 polychaetes, 22 crustaceans, 11 mollusks, 1 oligochaete, 1 actiniarian, 1 rhynchocoel, 1 sipunculid) were included in a matrix of station and species groups (Table 11) These taxa accounted for 88 2% of the macroinfaunal individuals collected (including certain indefinite taxa such as Oligochaeta [LPIL])

Numerical classification of survey stations was interpreted at an 8-group level (Figure 19) These groups were delineated at a level of similarity from 35 to 75%, indicating a low degree of homogeneity among stations within groups Station Groups A, B, C, and H were individual station groups containing Stations 42 (PA 221, RMD), 50 (PA 234, RMD), 32 (PA 214, RMD), and 54 (PA 236, RMD), respectively All four of these stations represented by low numbers of species and individuals were near-reference RMD stations Station Group E contained only two stations Interestingly enough, these were

Table 10 Benthic macroinfauna biomass for major taxonomic groups surveyed in Laguna Madre, Texas in May, 1996

STATION	SITE/REPL.	ANNELIDA	CRUST.	MOLLUSCA	ECHINO.	MISC.	TOTAL
1	183A (N1-S2)	0 6371	0 6701	2 2726	0 0069	0 0076	3 5943
3	183A (RN1-RS2)	0 5871	0 0288	0 5716	=====	0 0140	1 2014
5	183A (MD1-MD2)	1 4168	0 1608	4 7520	=====	0 0119	6 3414
7	183A (RMD)	0 3638	0 1794	1 8036	3 8998	0 0014	6 2480
8	183B (N1-S2)	0 8806	0 0164	1 0812	=====	0 0161	1 9943
10	183B (RN1-RS2)	0 7130	0 0241	0 3299	=====	0 0075	1 0744
12	183B (MD2)	1 3570	0 0826	1 2800	=====	0 0030	2 7226
7	183B (RMD)	0 3638	0 1794	1 8036	3 8998	0 0014	6 2480
13	198 (N1-S2)	0 6493	0 0265	1 5275	=====	0 0060	2 2092
14	198 (RN1-RS2)	0 0880	0 0104	0 2418	=====	0 0001	0 3402
15	198 (MD1-MD2)	2 2925	0 0120	0 7737	=====	0 0071	3 0852
16	198 (RMD)	0 2034	0 0006	3 1482	=====	=====	3 3522
17	197 (N1-S2)	0 3341	0 0150	0 4963	=====	0 0444	0 8897
18	197 (RN1-RS2)	0 6011	0 0136	0 9429	0 0029	0 0499	1 6103
19	197 (MD1-MD2)	0 7982	0 0608	0 3948	=====	0 0326	1 2863
20	197 (RMD)	0 1665	0 0039	0 3105	0 0060	0 0102	0 4971
21	192 (N1-S2)	0 3608	0 0040	0 7712	=====	0 0157	1 1517
22	192 (RN1-RS2)	0 6005	0 1243	0 3500	0 0021	0 0084	1 0852
23	192 (MD1-MD2)	1 5558	0 0023	0 5228	=====	0 0357	2 1165
24	192 (RMD)	0 7050	0 0057	0 8223	5 0949	0 0063	6 6342
25	190 (N1-S2)	0 6083	0 6307	2 5806	0 0014	0 0004	3 8213
26	190 (RN1-RS2)	0 6801	0 0346	0 1728	0 0001	0 0074	0 8948
27	190 (MD1-MD2)	1 5624	0 0005	0 0678	=====	0 0228	1 6535
28	190 (RMD)	0 1695	0 0033	0 0054	=====	0 0033	0 1815
29	214 (N1-S2)	0 7445	0 0382	0 1111	0 0376	0 0041	0 9355
30	214 (RN1-RS2)	0 3875	0 0070	0 0069	0 4005	0 0063	0 8082
31	214 (MD1-MD2)	0 8151	0 0064	0 0105	=====	0 0127	0 8447
32	214 (RMD)	0 3192	0 0018	0 0050	=====	0 0048	0 3308
33	219 (N1-S2)	0 2376	0 0018	0 0360	0 0103	0 0237	0 3095
34	219 (RN1-RS2)	0 2908	0 0060	0 1024	0 0214	0 0243	0 4449
35	219 (MD1-MD2)	0 2358	0 0065	0 0408	0 0613	0 0011	0 3455
36	219 (RMD)	0 2894	0 0032	0 0564	0 2662	0 0118	0 6270
37	221 (N1-S1)	0 6081	0 0823	2 4797	=====	0 0152	3 1854
39	221 (RN1-RS2)	0 4253	0 0484	2 7363	0 0719	0 0162	3 2980
41	221 (MD1-MD2)	0 5088	0 0687	0 7801	=====	0 0191	1 3766
42	221 (RMD)	0 0672	0 0153	2 4643	=====	0 0075	2 5543
43	229 (N1-S2)	1 2271	0 5919	3 5923	=====	0 0093	5 4206
44	229 (RN1-RS2)	0 5517	0 4465	1 7732	=====	0 0133	2 7846
45	229 (MD1-MD2)	0 5770	0 9470	1 5398	=====	0 0111	3 0749
46	229 (RMD)	0 2272	0 0036	0 4150	=====	=====	0 6458
47	234 (N1-S2)	0 4403	0 4019	2 8142	0 0799	0 0318	3 7680
48	234 (RN1-RS2)	0 5158	0 0066	1 0762	0 0015	1 4566	3 0567
49	234 (MD1-MD2)	1 5308	0 0157	1 2231	0 3785	0 0255	3 1736
50	234 (RMD)	0 2682	0 0056	0 2940	=====	0 0108	0 5786
51	236 (N1-S2)	0 1692	0 8069	2 3301	1 2302	0 0064	4 5429
52	236 (RN1-RS2)	0 6092	0 1781	0 5921	0 0947	0 0088	1 4830
53	236 (MD1-MD2)	0 1525	0 0453	0 0122	=====	0 0002	0 2102
54	236 (RMD)	0 2170	0 0472	0 0326	0 0280	0 0114	0 3362

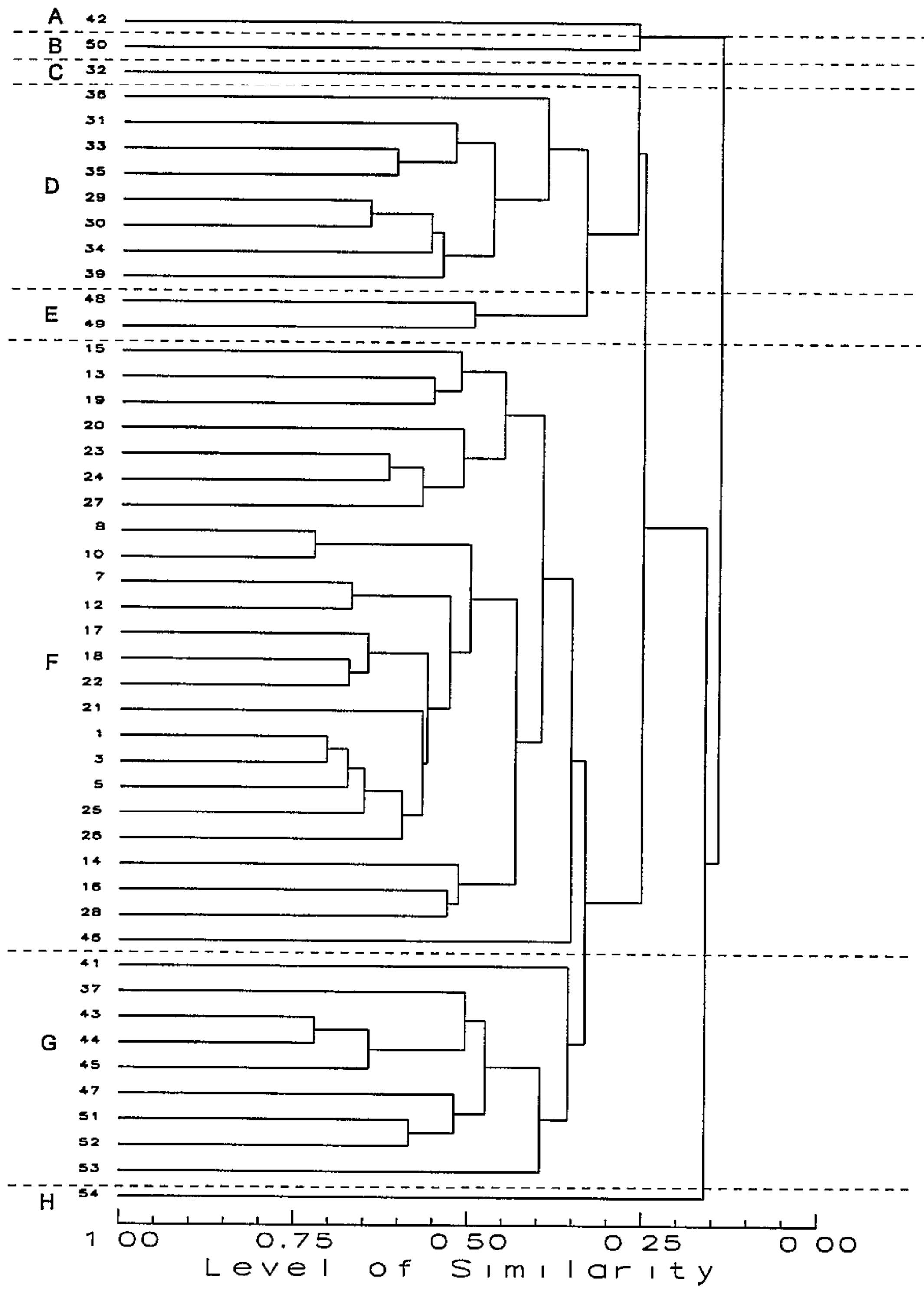


Figure 18 Normal (station) numerical classification analysis dendrogram for the Laguna Madre, Texas study, May, 1996

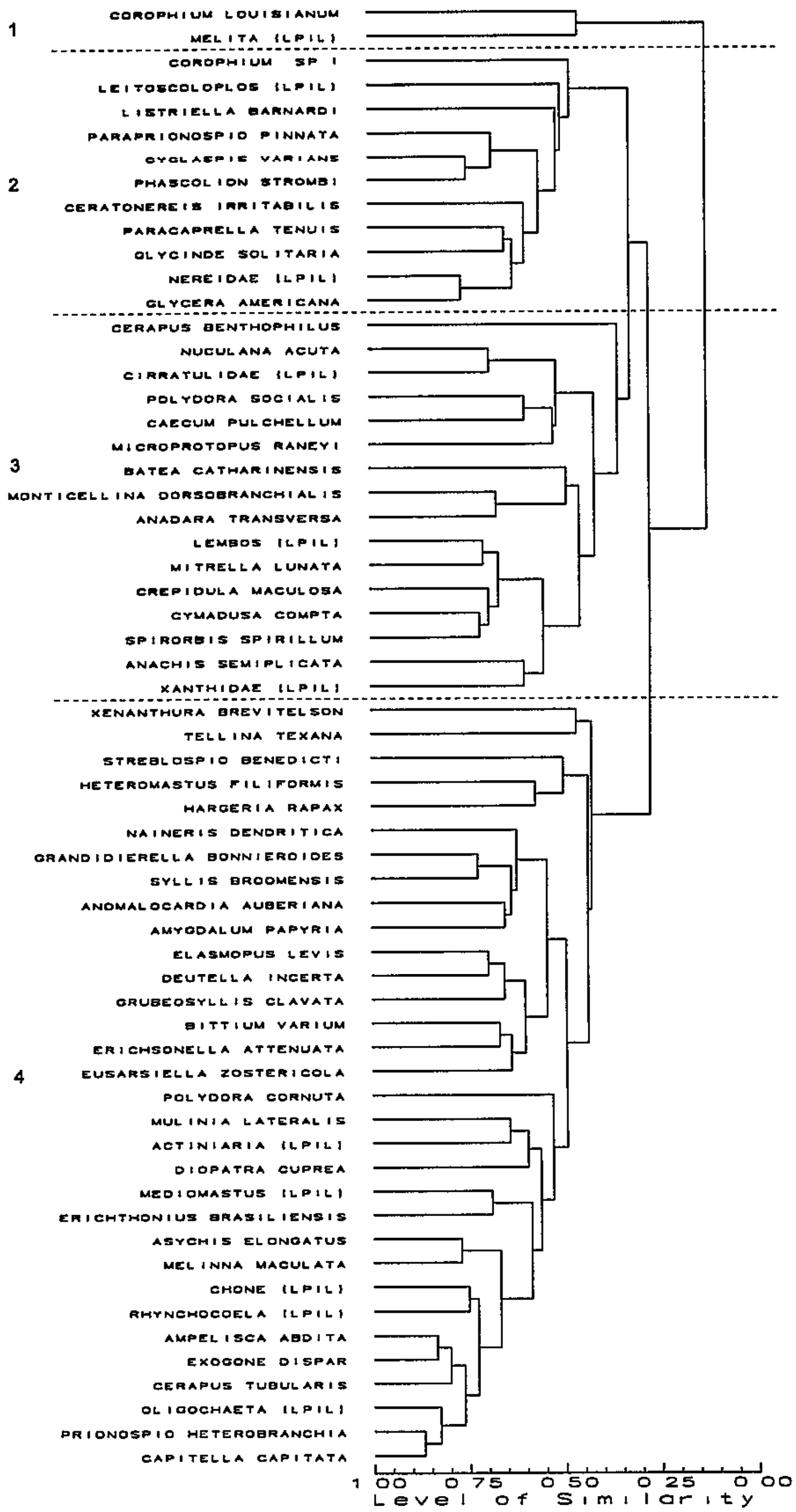


Figure 19. Inverse (species) numerical classification analysis dendrogram for Laguna Madre, Texas, May 1996

TABLE 11

Two-way matrix of station and species groups compiled from classification dendrograms for Laguna Madre, Texas, May, 1996

	A	B	C	D								E		F																								G									H	
	42	50	32	36	31	33	35	29	30	34	39	48	49	15	13	19	20	23	24	27	8	10	7	12	17	18	22	21	1	3	5	25	26	14	16	28	46	41	37	43	44	45	47	51	52	53	54	
Corophium louisianum														40	104												4					8	136															1
Melita (LPIL)																								24	16							20	148															
Corophium (LPIL)				4		2		4		14	6	2	14		52			4				4			4					4			48					1	26	14		2	20	22	30			
Leitoscoloplos (LPIL)	14	10		4				4	20	4	45	68									2						4			4								1	17	16	2	2	14					
Listriella barnardi	6	6		4	6	2		20	18	16	14	20	8		12			8		4	10				12																				2			
Paraprionospio pinnata				2	12	182	70	4	34	102	6	2																															8	4		2		
Cyclaspis varians			2	4	22	20	4	56	56	16	8	32	2																										4				16					
Phascolion strombi	2	2	2	4	8	16	2	20	18	60	28	4																										1					2					2
Ceratonereis irritabilis	10				6	10		42	30	44	19	8	6	8	4										4				4	4			4					8	42	36	8	14	6					
Paracaprella tenuis			8	2	4	26	12	122	30	14	3	6	4	4	44											4	4			2							2		22	56	8	10	112	20	114	20		
Glycinde solitaria	2			2	2	22	4	6	18	22	4	10	4		12			4			12					8														2	4	2	12		10	6		
Nereidae (LPIL)						8	2	30	12	28	6	4	8																										6	8	4	2	44	10	4		2	
Glycera americana					8	4	2	12	14	24	9	8																										4	14	4	6		12	2	10	4	2	
Cerapus benthophilus																12										12	8											11	64				4	10	26			
Nuculana acuta		6									2	50	62																			4											170		2			
Cirratulidae (LPIL)		6									4	34	6																										2				68	28	34			
Polydora socialis		2									2	16	22																	4								84	46	32	24		34	12	4			
Caecum pulchellum				8							29	12	2											2						16	2	4	4							10	26		118	14	2			
Microprotopus raneyi	12		4		2			4			6	20	2																										4		14		12	84	10			
Batea catharinensis					4	2	16	16	4		4		2		4																									4			80	40	98	28		
Monticellina dorsobranchialis												8	12																										2				8	40	226	2	10	3
Anadara transversa																																											12	38	122			
Lembos (LPIL)								10								4													30	2				4			2		41	28	28	10	110	84	24	28		
Mitrella lunata				2		2		6	2																													1	38	78	22	8	70	28	78			
Crepidula maculosa												2	2										2						2	4							2	2	12	74	100	42	16	102	154	18	12	
Cymadusa compta											9															16							12				4		20	122	64	8	100	96	84	32		
Spirorbis spirillum											3																													88	2	4	44	90	32	30	6	
Anachis semiplicata																							2					4		4								2		70	12	6	4	24	10			
Xanthidae (LPIL)							4	2						4									2				8			8			8						4	34	2		16	36	10			
Xenanthura brevitelson		6	2					2	20			14	8								258	384	88	78					62	494	4		340						33	22	16	8	32		2			
Tellina texana	2							2			5	4	2							4	32	12					16	8		6	4	16						4	8	6	10	8	4		4			
Streblospio benedicti		2				6		10				32			8		160					10			44	8	48	4	4				24	12		4	32	104	2	1172	216	8	2	68				
Heteromastus filiformis								8			2										2						4	36	12	28	4	4					14	43	2	638	968	284	76	2				
Hargeria rapax								4			1												24	4	8				8	94	12					8	8	61	242	136	76	10		22	4	10		
Naineris dendritica																					2		26	132	20			84	208	16	156	208	72	16		4												
Grandidierella bonnieroides									2						8		4		8		14		106	104	140	92	200	4	98	140	388	88	84	12	4	20	2		6	50	22	22		2		8		
Syllis broomensis							2								4			4	4			8	28	148	8	4	68	28	80	112	186	52	144	4	12	16	4			4	8		6	2	6		2	
Anomalocardia auberiana	2			2				2		2	2			20	12	4	8	24			64	68	22	8	16	52	36	44	78	40	60	128	4	16	36		2				4							
Amygdalum papyria					2			4	2		2			8	12				4		6		8	4	8			16	70	26	82	80	8	4	12	4			4	2	6		2					
Elasmopus levis								20	2				2		12	4			4		4		28	94	16	32	44	4	8	76	100	48	148				12		50	1978	20	220	150	368	50	72	2	
Deutella incerta								12							20	8	8								16	40	28		4	6	24	32	28	4					2	152	36	38		32	174	26	4	
Grubeosyllis clavata	2							10			3	2			4	4	12			8	4	4	4		28	32	8		46	18	26	40	96		44		2		10	32	2		4	24	10	10		
Bittium varium								2														6	4	12	4			8	28	84	4	44	4	24			6		1	308	64	188	142	54	2	4	6	
Erichsonella attenuata								2								4			4				6		24	24	28	16	28	50	88	32	4	36				3	1	64	46	14	28		10			4
Eusarsiella zostericola								2				2			8						10	14	10	12	4		24		14	24	88	20	32					1		12	34	6	12	2	2			
Polydora cornuta						6		6			3				100	52	12	28	16	128					4	16	88	16		4		20	132	6	24			3		50	12		4			2		
Mulinia lateralis	30					50	6	18		50	82	6	10	36	120	36	12	16	4		24	8			60	96	4	16		2		28	4		12		2		41	82	20	2	58					
Actiniaria (LPIL)				4					4	2	5	12	10	36	84	20	16	8		8	4	4		2	228	88	8	60	14	18	8	4	16					1	14	8	6	4	6	6	2		4	
Diopatra cuprea			2	2	20	12	4	46	14	10	2		4	52	104	12		16	8	12	38	38			20	4	8	4		2			4	8				2	3	2			4	4				
Mediomastus (LPIL)	64	44	6	90	46	178	24	272	254	442	308	340	184	4	56	28	28	16	20	24	208	106	8		44		8		10	20		4	38					51	320	80	22	4	344	36	312	6	6	
Erichthonius brasiliensis					8	18	14	210	40	52	46	4	28		216	48	8	8		12					24	8	12			4			32	12		4		8	52	14	134	2	160	90	292	46	4	
Asychis elongatus			6		38	42	26	178	124	8	4	2	4	456	384	496	12	316	92	56	752	394	6		292	448	44		10	74		4	244			8			1	14	4	6	6	2	4			
Melinna maculata			10	10	4	14	4	34	40	12	48	4	12	48	44	76	16	64	76	16	626	342	22	2	36	60	104	88	88	158		116	212		4	12	4	16	3	64	176	82	14	2	2		2	
Chone (LPIL)			2					16	10	2	15			4				20	16	12	24	120	28	18	20	8	52	32	114	170	60	104	220		28	4	20	9	12	146	260	12	10	2				
Rhynchocoela (LPIL)	2		2	2		8	2	22	6	8	15	6	4	4	16	12	16	16	4	32	38	22	10	14	8	44	108	8	40	74	64	88	80	4		8		7	44	42	16	4	32	22	10			
Ampelisca abdita					4	4	4	6	20	10	193		2	92	652	64	4	36	12	6	602	704	16	10	240	164	96	76	50	116	68	20	96	64	16		8	128	128	614	414	268	382	228	38	70		
Exogone dispar	2				12	8		42	8		72	4		28	58	12	8	16	12	80	30	36	28	28	92	344	380	108	308	366	78	52	432	36	72	40	40	15	112	500	104	42	308	190	28	40		
Cerapus tubularis			4	2	4	16	12	234	18		33		4	36	148	112			8	12	72	22	8	12	280	296	120	44	4	84	64	44	120	648	4	12	2		106	174	238	26	120	6	68	8		
Oligochaeta (LPIL)			8					28	26		1	6			20		72	8	12	116	182	172	12	704	624	776	3000	1792	1090	312	20	996	1212	120	164	48	10	22	6	292	68	62	58	212	50	84		
Prionospio heterobranchia								10	8		5						12	12	12	20	78	80	82	104	120	52	704	392	588	1166	132	1260	756	44	144	208	56	10	19	304	280	300	98	118	48	26	2	
Capitella capitata				2		2	2	50	12	6	8	2				4	12	8	8	28	32	60	36	24	60	12	44	308	440	640	76	1132	216	48	100	8		27	202	198	244	220	26	40	60	16	2	

Stations 48 (PA 234, RN1-RS2) and 49 (PA 234, MD1-MD2) Station Group D contained eight stations and Station Group F was very large, with 24 of the 47 stations Station Group G contained 9 stations The stations were grouped mainly according to placement area (except for the single-sample stations) Station Groups D and G included mainly lower Laguna stations Station Group D contained primarily PAs 214 (except for RMD) and 219 (all), plus PA 221, RN1-RS2, while Group G was comprised primarily of stations in PAs 229 and 236 (except for RMDs), plus PA 221, MD1-MD2 and PA 234, N1-S2 Station Group F represented the remaining PAs, all in the upper Laguna except for Station 46 (PA 229, RMD) Station 46 (PA 229, RMD) is the most dissimilar of the stations included in Station Group F and Station 36 (PA 219, RMD) is the most dissimilar of the stations included in Station Group D. Station Groups did not correspond closely to sediment types, but in some cases did relate to presence/absence of seagrasses: Group D stations contained no seagrasses, while Group G stations contained either *Halodule, Thalassia,* or *Syringodium* beds However, Group F included both grassbed and non-grassbed stations The fact that the RMD stations tended to separate from the other reference stations may indicate that nearness or farness from the GIWW plays a role in benthos composition However, only three of the MD1-MD2 stations tend to separate out Station 54 (PA 236) and Station 41 (PA 221) in Station Group G and Station 49, one of the two-station Station Group E The other MD1-MD2 stations (Stations 5, 12, 19, 23, 27, 31, 35, and 45) are nestled in Station Groups D, F, or G.

Examples of the lack of difference between PA stations (N1-S2) and reference stations (RN1-RS2), at a given PA, are provided by the most similar stations in Station Group D (Stations 29 and 30, PA 214), Station Group F (Stations 8 and 10, PA 183B, Stations 1 and 3, PA 183A), and Station Group G (Stations 43 and 44, PA 229) For six others, the N1-S2 and RN1-RS2 stations are in the same subgroup of a Station Group (Stations 51 and 52, PA 236, Stations 25 and 26, PA 190, Stations 21 and 22, PA 192, Stations 17 and 18, PA 197) or are in the same Station Group (Stations 33 and 34, PA 219, Stations 13 and 14, PA 198). For only two PAs were the N1-S2 and RN1-RS2 stations in separate Station Groups Stations 47 and 48, PA 234, Stations 37 and 39, PA 221)

Classification of the 61 taxa was interpreted at a 4-group level (Figure 19) These groups were delineated at a 33% to 87% level of similarity, which indicated moderate heterogeneity among species groups Species Group 1 contained two species of crustaceans (*Corophium louisianum* and *Melita* [LPIL]) Species Group 2 contained 11 species, including four crustaceans and six polychaetes Species Group 3 included 16 species, including five crustaceans and six mollusks Species Group 4 contained 32 species, representing 10 crustaceans and 14 polychaetes The most abundant taxa (Oligochaeta [LPIL] and *Prionospio heterobranchia*) were included in Species Group 4

4.2.1 3 Relationships Between Sediments and Benthic Communities

As noted above in the comparison of N1-S2 and RN1-RS2 stations for the various PAs, benthic assemblages in the Laguna Madre site exhibited minimal impacts from dredged material placement practices. Differences in infaunal taxa and individual abundances were related primarily to PA location and presence/absence of grassbeds The presence of very broadly-defined station and species groupings (Table 11) indicated that habitat differences were generally not great enough to elicit clear distinctions in infaunal assemblages. This is reflected, too, in the general absence of strong patterns of sediment distribution

Dredged material placement activities in the area date back to at least 1950, with the most recent dredging and placement occurring in 1995-1996. When selected benthic macroinfaunal community parameters are compared, it appears that most stations within PAs contained more abundant and diverse macroinfauna than do adjacent reference stations for the most recent placements (Table 12) In Table 12, the differences between community parameters at reference versus PA stations are negative when PA station values are higher. Five of six sites where dredged material was placed two years prior to the May 1996 benthic collection exhibited higher numbers of species, individuals, diversity, and evenness PA 219, where reference station benthos were more abundant that benthos at stations within the PA, was the only recently used PA where the sediment texture within a PA exhibited a significant shift from sand to clay (see Table 5) The high proportion of clay at the stations in the PA (37 2%) could have produced lower infaunal abundances. Older PAs generally contained less abundant and diverse benthos. PAs used as much as 13 years prior to May 1996 (i e , PAs 183A and 183B) contained similar sediments at the reference and within-PA stations, reference station benthos for PA 183A (which contained seagrasses) were richer than PA-station benthos In PA 183B stations (unvegetated), the benthos were more abundant within the PA than at the reference stations

Composition of benthic assemblages reflected geographic rather than placement-related trends Species censused in the May 1996 survey were classified with respect to their status as indicators of one of the following three stages of community succession

Group I Opportunistic species prevalent during early succession,
Group II Intermediate species found in mid-succession habitats;

TABLE 12

Comparısons between benthıc macroınfaunal communıty parameters at reference statıons versus dısposal monıtorıng statıons wıth respect to years sınce the PAs were last used

Placement Area	No Years Since Most Recent Disposal	DIFFERENCES BETWEEN REFERENCE AND DISPOSAL STATIONS			
		Total # Taxa	Total # Indiv	Pielou's Diversity	Pielou's Evenness
197	1	-7	204	-0 25	-0 04
198		-22	-1412	-1 01	-0 16
214		-13	-902	-0 09	0 01
219		16	332	0	-0.05
221		-10	-1221	-0 16	-0 02
234	2	-42	-2900	00 28	-0 01
190	7	3	404	0 47	0 09
192		10	2144	-0 01	-0 03
229	9	-2	-4100	017	0 04
236		36	248	0 20	0
183A	13	8	778	0 15	0 02
183B		-1	-764	0 08	0 02

Group III Near-equilibrium species associated with relatively stable, less-disturbed habitats.

Table 13 summarizes the species associated with these groupings, based on life history and habitat requirements. When these species groups were compared to the two-way matrix (Table 11), it was evident that succession Group I species were most prevalent in species Group 4, and further, that these taxa generally were most abundant at stations sampled in the Upper Laguna Madre (i e , PAs 183A, 183B, 190, 192, 197, 198) Succession Group II species were more ubiquitous and exhibited little correspondence with geographic location Succession Group III species, on the other hand, were most concentrated in species Groups 2 and 3, and were best represented at station Groups D and G, which included stations in the Lower Laguna Madre (PAs 214, 219, 221, 229, 234, and 236) Dredged material placement timing was similar in the Upper and Lower Laguna Madre, and few clear distinctions exist in sediment texture or benthic macroinfauna, that would indicate habitat differences caused by placement practices.

4 2 2 Fall 1996

4 2.2.1 Faunal Composition, Abundance, and Community Structure

A total of 26,015 individuals representing 308 taxa was identified from 177 discrete samples (Table 14). This was roughly two-thirds the abundance observed in the Spring survey, and represented a decrease that is typical for the Fall season in the northern Gulf of Mexico region Polychaetes comprised the majority of individuals (13,024 or 50.1%), and the greatest number of taxa (140 or 45.5%). The most abundant species-level taxon collected was the polychaete *Exogone rolani* (1684 individuals or 6 5%) (Table 15) The second most abundant species was the polychaete *Prionospio heterobranchia* (1428 individuals or 5.5%) (Table 15) Oligochaeta (LPIL) comprised 28.3% of all individuals, but probably included more than one species. The taxon with the highest frequency occurrence was *Exogone rolani* , which was present at 36 of the 49 stations This species was not identified during the May survey, possibly because new literature became available to distinguish this species from *E. dispar*, which was numerically dominant in the previous survey. Both *E. rolani* and *E dispar* were found in the Fall samples (See Appendix B for a listing of taxa)

Amphipod crustaceans were the second most abundant group with respect to individuals (1,892 or 7 3%), which represented a significant drop from Spring, 1996 when amphipods comprised nearly 24% of all individuals. All Crustacea (including amphipods) represented the second-greatest number

Table 13 Benthic macroinfaunal indicator species found in Laguna Madre in May 1996, arranged according to habitat/stage groups

GROUP I (Opportunistic Species; Early Succession)
Mediomastus spp. (P)
Prionospio heterobranchia (P)
Capitella capitata (P)
Heteromastus filiformis (P)
Polydora spp (P)
Grandidierella bonnieroides (C)
Bittium varium (M)
Xenanthura brevitelson (C)
Mulinia lateralis (M)
GROUP II (Intermediate Species; Mid-Succession)
Melinna maculata (P)
Nuculana acuta (M)
Corophium spp (C)
Asychis elongatus (P)
Ampelisca abdita (C)
Cerapus tubularis (C)
Hargeria rapax (C)
Ceratonereis irritabilis (P)
Nainereis dendritica (P)
GROUP III (Near-Equilibrium Species; Stable Habitats)
Diopatra cuprea (P)
Amygdalum papyria (M)
Crepidula maculosa (M)
Caecum pulchellum (M)
Mitrella lunata (M)
Phascolion strombi (S)
Glycinde solitaria (P)
Glycera americana (P)
Anadara transversa (M)
Listriella barnardi (C)

Table 14 Taxonomic listing and abundance of major Phyla from Laguna Madre, Texas survey, October 1996

TAXON	NO. OF INDIVIDUALS	% TOTAL	NO OF TAXA	% TOTAL
ANNELIDA				
POLYCHAETA	13024	50 1	140	45 5
OLIGOCHAETA	7367	28 3	1	0 3
MOLLUSCA				
PELECYPODA	994	3 8	35	11.4
GASTROPODA	1388	5 3	43	14 0
OTHER MOLLUSCA	34	0 1	3	1 0
ARTHROPODA (CRUSTACEA)				
AMPHIPODA	1892	7 3	32	10 4
OTHER CRUSTACEA	746	2 9	37	12 0
OTHER TAXA	570	2 2	17	5 5
TOTAL	26015		308	

Table 15 Taxonomic listing and abundance of numerically dominant taxa from Laguna Madre, Texas survey, September - October, 1996.

TAXON	Phylum	Class	NO INDIVS	% TOTAL	CUMULATIVE %	STATION OCCURRENCE	% STATION OCCURRENCE
Oligochaeta (LPIL)	A	Olig	7367	28 3	28 3	39	84 8
Exogone rolani	A	Poly	1684	6 5	34 8	36	78 3
Prionospio heterobranchia	A	Poly	1428	5 5	40 3	32	69 6
Syllis broomensis	A	Poly	1409	5 4	45 7	28	60 9
Streblospio benedicti	A	Poly	1245	4 8	50 5	24	52 2
Mediomastus (LPIL)	A	Poly	938	3 6	54 1	22	47 8
Prionospio (LPIL)	A	Poly	755	2 9	57 0	21	45 7
Grandidierella bonnieroides	Ar	Mala	639	2 5	59 4	28	60 9
Polydora cornuta	A	Poly	577	2 2	61 6	22	47 8
Diastoma varium	M	Gast	547	2 1	63 7	16	34 8
Monticellina dorsobranchialis	A	Poly	423	1 6	65 4	10	21 7
Rhynchocoela (LPIL)	R		382	1 5	66 8	39	84 8
Maldanidae (LPIL)	A	Poly	372	1 4	68 3	31	67 4
Heteromastus filiformis	A	Poly	358	1 4	69 6	8	17 4
Capitella capitata	A	Poly	351	1 3	71 0	26	56 5
Spirorbis (LPIL)	A	Poly	328	1 3	72 3	13	28 3
Anomalocardia auberiana	M	Pele	311	1 2	73 5	23	50
Spionidae (LPIL)	A	Poly	294	1 1	74 6	24	52 2
Asychis elongatus	A	Poly	266	1 0	75 6	25	54 3
Melinna maculata	A	Poly	260	1 0	76 6	34	73 9
Cymadusa compta	Ar	Mala	259	1 0	77 6	16	34 8
Xenanthura brevitelson	Ar	Mala	257	1 0	78 6	19	41 3
Fabricinuda trilobata	A	Poly	252	1 0	79 6	9	19 6
Grubeosyllis clavata	A	Poly	249	1 0	80 5	25	54 3
Veneridae (LPIL)	M	Pele	164	0 6	81 1	15	32 6
Crepidula maculosa	M	Gast	163	0 6	81 8	12	26 1
Aeginellidae (LPIL)	Ar	Mala	152	0 6	82 4	18	39 1
Chone (LPIL)	A	Poly	141	0 5	82 9	25	54 3
Cerapus tubularis	Ar	Mala	139	0 5	83 4	12	26 1
Capitellidae (LPIL)	A	Poly	138	0 5	84 0	15	32 6
Erichthonius brasiliensis	Ar	Mala	128	0 5	84 5	16	34 8
Odostomia impressa	M	Gast	118	0 5	84 9	11	23 9
Naineris setosa	A	Poly	115	0 4	85 4	7	15 2
Carazziella hobsonae	A	Poly	115	0 4	85 8	13	28 3
Cirratulidae (LPIL)	A	Poly	104	0 4	86 2	12	26 1
Cerithium lutosum	M	Gast	96	0 4	86 6	15	32 6
Elasmopus levis	Ar	Mala	94	0 4	86 9	8	17 4
Elasmopus (LPIL)	Ar	Mala	93	0 4	87 3	15	32 6
Harrieta faxoni	Ar	Mala	92	0 4	87 6	18	39 1
Mulinia lateralis	M	Pele	85	0 3	88 0	11	23 9
Nuculana acuta	M	Pele	82	0 3	88 3	4	8 7
Nereidae (LPIL)	A	Poly	76	0 3	88 6	21	45 7
Crepidula (LPIL)	M	Gast	76	0 3	88 9	8	17 4
Caecum pulchellum	M	Gast	75	0 3	89 2	18	39 1
Diopatra cuprea	A	Poly	72	0 3	89 4	16	34 8
Erichsonella attenuata	Ar	Mala	72	0 3	89 7	17	37
Scoloplos rubra	A	Poly	67	0 3	90 0	16	34 8
Mysella planulata	M	Pele	60	0 2	90 2	8	17 4
Syllis (LPIL)	A	Poly	58	0 2	90 4	3	6 5
Hargeria rapax	Ar	Mala	58	0 2	90 6	20	43 5
Actiniaria (LPIL)	C	Anth	57	0 2	90 9	17	37
Glycinde solitaria	A	Poly	55	0 2	91 1	16	34 8
Amygdalum papyria	M	Pele	54	0 2	91 3	19	41 3
Mediomastus californiensis	A	Poly	53	0 2	91 5	7	15 2
Pelecypoda (LPIL)	M	Pele	52	0 2	91 7	20	43 5
Batea catharinensis	Ar	Mala	52	0 2	91 9	5	10 9
Aoridae (LPIL)	Ar	Mala	52	0 2	92 1	14	30 4
Mitrella lunata	M	Gast	51	0 2	92 3	11	23 9
Neopanope texana	Ar	Mala	50	0 2	92 5	17	37
Listriella barnardi	Ar	Mala	48	0 2	92 7	12	26 1
Anachis semiplicata	M	Gast	43	0 2	92 8	10	21 7
Ampelisca (LPIL)	Ar	Mala	42	0 2	93 0	12	26 1
Exogone (LPIL)	A	Poly	40	0 2	93 1	9	19 6
Spirorbis spirillum	A	Poly	39	0 2	93 3	5	10 9
Dipolydora socialis	A	Poly	38	0 1	93 4	5	10 9
Chione cancellata	M	Pele	37	0 1	93 6	12	26 1
Amphilochus neopolitanus	Ar	Mala	37	0 1	93 7	6	13

Taxa Key

Phylum
Class
A = Annelida
Olig = Oligochaeta
Poly = Polychaeta

Phylum
Class
Ar = Arthropoda
Mala = Malacostraca

Phylum
Class
C = Cnidaria
Anth = Anthozoa

Phylum
Class
M = Mollusca
Gast = Gastropoda
Pele = Pelecypoda

Phylum
R = Rhynchocoela

of taxa (69 or 22 4%) Decreases in amphipod abundances are normal for estuarine systems in the Fall season.

Mollusks (including pelecypods and gastropods) contributed the third highest numbers of individuals (2,416 or 9.2%), and 81 taxa (26 4%). *Diastoma (Bittium) varium*, an opportunistic gastropod, was the most abundant mollusk, as in the May survey, and ranked 10th in individual abundance (547 or 2 1%).

Other phyla (Echinodermata, Bryozoa, Phoronida, Platyhelminthes, Sipuncula, Urochordata, Cnidaria, Rhynchocoela) comprised 2.2% of the individuals and 5 5% of the taxa during the September - October, 1996 survey; these percentages were very similar to those observed in the May survey The most abundant such taxon was Rhynchocoela (LPIL), which was represented by 382 individuals (1.5%). Eleven phyla were represented in the Fall, 1996 survey, as in the Spring survey Of the 15 most-abundant taxa censused during the Fall survey, 8 were also listed among 15 numerically dominant taxa during the Spring survey Oligochaeta (LPIL) was by far the most abundant taxon in both surveys

Community statistics by station are summarized in Table 16, and reflect a high degree of dissimilarity between PAs, but moderate similarity between stations in and near the various PAs Taxon abundance varied from 8 at PA 198 (MD1-MD2) to 123 at PA 236 (RN1-RS2), and averaged 39.8 taxa for the 47 stations versus 54.9 in the Spring survey Excluding single-sample stations, the number of species censused was generally higher in the lower Laguna Madre than in the upper Laguna Madre, during Fall 1996 This trend was also observed during the Spring 1996 survey, but was less distinct. Statistical comparison of taxa numbers by station determined that species abundance during the Fall was significantly lower than during the Spring, 1996 ($\alpha < 0$ 001). The highest mean density (number of individuals/m^2) was observed at PA 221(N1-S2), with 73,262 individuals/m^2. The lowest mean density was found at PA 198 (MD1-MD2) with 643 individuals/m^2 PAs 229 and 236 consistently had the highest individual abundances, while lowest abundances were found at PAs 198 and 214. Comparison of stations within the disposal areas with reference stations indicated that reference stations had much lower densities (and lower numbers of species) at PAs 183A, 197, and 221, although differences in number of individuals and number of taxa were only significant ($\alpha = 0$ 05) at PA 221 At PA 236, individual abundances were similar, but species abundance was much higher at the reference station, although not statistically significant Species abundances at the reference stations were higher at eight of the 12 PAs, although not statistically significant, primarily because of high variance These comparisons were different from those observed for the Spring 1996 survey, when reference and disposal area stations were more similar.

Table 16 Summary of benthic assemblage parameters for Laguna Madre, Texas study transects, September - October, 1996.

STATION (BVA)	SITE/REP	TOTAL # TAXA	MEAN TAXA/ REP	TOTAL # INDIVID	DENSITY (MEAN)	DENSITY (STD DEV)	H'	J'	D
1	183A (N1-S2)	52	18 3	948	11286	9733	2 72	0 69	7 44
2	183A (RN1-RS2)	43	14 8	459	5464	4118	2 88	0 77	6 85
3	183A (MD1-MD2)	17	12	172	6143	1717	1.92	0 68	3 11
4	183A (RMD)	13	13	112	8000	0	1.91	0 74	2 54
5	183B (N1-S2)	28	10 3	173	2060	1041	2 54	0 76	5 24
6	183B (RN1-RS2)	39	13 2	305	3631	2549	2 68	0 73	6 64
7	190 (N1-S2)	38	11.8	753	8964	7010	2 28	0 63	5 59
8	190 (RN1-RS2)	32	14 3	943	11226	6184	1 98	0 57	4 53
9	190 (MD1-MD2)	29	19 5	237	8464	1364	2 67	0 79	5.12
10	190 (RMD)	11	11	162	11571	0	1 50	0 63	1 97
11	192 (N1-S2)	39	14 2	774	9214	8742	2 25	0.61	5 71
12	192 (RN1-RS2)	42	14 2	704	8405	6510	2 12	0.57	6 25
13	192 (MD1-MD2)	13	8	47	1643	0	1.77	0 69	3 12
14	192 (RMD)	18	18	283	20214	0	1 56	0 54	3 01
15	197 (N1-S2)	40	11 2	818	9738	17803	2 33	0 63	5 81
16	197 (RN1-RS2)	33	9.5	295	3512	2788	2 09	0 60	5.63
17	197 (MD1-MD2)	30	15 5	165	5893	8233	2 98	0 88	5.68
18	197 (RMD)	26	26	225	16071	0	2.44	0 75	4 62
19	198 (N1-S2)	13	4 3	89	1060	1223	1 81	0.71	2 67
20	198 (RN1-RS2)	23	5 2	121	1440	2339	2 58	0 82	4 59
21	198 (MD1-MD2)	8	4	18	643	909	1 61	0 77	2 42
22	198 (RMD)	20	20	246	17571	0	1 69	0 56	3 45
23	214 (N1-S2)	36	7 7	134	1595	1918	3 09	0 86	7.15
24	214 (RN1-RS2)	38	11	151	1798	1187	2 87	0 79	7.37
25	214 (MD1-MD2)	10	6	20	714	707	2 15	0 93	3 00
26	214 (RMD)	20	20	57	4071	0	2 39	0 80	4 70
27	219 (N1-S2)	43	13 2	154	1833	1091	3 29	0 89	8.35
29	219 (RN1-RS2)	47	15	166	1976	1033	3 39	0 88	9.00
30	219 (MD1-MD2)	20	13 5	56	2000	505	2 51	0 84	4.72
31	219 (RMD)	12	12	19	1357	0	2 30	0 93	3 74
32	221 (N1-S2)	109	42.7	6154	73262	88748	1 66	0 35	12.30
33	221 (RN1-RS2)	63	15 8	281	3345	3472	3 38	0 82	11 00
34	221 (MD1-MD2)	41	25	156	5571	2424	3 32	0 89	7 92
35	221 (RMD)	14	14	31	2214	0	2 39	0 91	3 79
36	229 (N1-S2)	74	30 7	1766	21024	15331	2 92	0 68	9 76
37	229 (RN1-RS2)	87	32 2	2230	26548	22962	3 15	0 71	11 10
38	229 (MD1-MD2)	39	32	422	15071	3334	2 83	0 77	6 29
39	229 (RMD)	34	34	762	54429	0	2 47	0 70	4 97
40	234 (N1-S2)	101	27 5	461	5488	1824	3 91	0 85	16 30
41	234 (RN1-RS2)	112	31 8	537	6393	6070	4 01	0 85	17.70
42	234 (MD1-MD2)	63	34	504	18000	19698	3 16	0 76	9 96
43	234 (RMD)	29	29	60	4286	0	3 12	0 93	6 84
44	236 (N1-S2)	78	30 7	1755	20893	28360	3 24	0 74	10 31
45	236 (RN1-RS2)	123	32 2	1358	16167	15160	3 61	0 75	16 91
46	236 (MD1-MD2)	34	21 5	567	20250	23183	1 60	0 45	5 20
47	236 (RMD)	39	39	157	11214	0	2 87	0 78	7 52

PA 234 (RMD) was shown to have the highest H' value at 4.01, while the lowest diversity was measured at PA 190 (RMD) with an H' of 1.50 The high diversity at PA 234 (RN1-RS2) was due to a speciose (112 taxa) and even polychaete, crustacean and molluscan assemblage The low diversity at PA 190 (RMD) was due mainly to the dominance of the annelids, Oligochaeta (LPIL) and *Syllis broomensis*, and low species abundance (11 taxa) Other stations with low diversity included PA 192 (RMD), PA 198 (MD1-MD2 and RMD), PA 221 (MD1-MD2), and PA 236 (MD1-MD2). Disposal area and reference stations within study PAs were not notably different with respect to species diversity, except that reference stations at PAs 198, 221, and 236 had much higher diversities than did the disposal stations at those PAs During the Spring 1996 survey, the PA 198 reference station diversity was much lower than the disposal station, due to a lower number of species. In the Fall 1996 survey, the biggest difference in diversities occurred at PA 221, and was attributed to extreme numerical dominance of Oligochaeta (LPIL) and to lower species abundance at PA 221 (N1-S2) When all stations were compared statistically, it was determined that species diversity was significantly lower in the Fall than in the Spring, 1996 ($\alpha < 0\ 005$)

Stations listed above as having lower diversity due to higher proportions of a few taxa also had relatively low values of J' For example, lowest J' (0 35) was observed at PA 221 (N1-S2), which had a diversity of 1 66. A J' value of 0.54 at PA 192 (RMD) was attributed to very high proportions of Oligochaeta (LPIL) The highest J' values (0 93) occurred at stations where few species and few individuals were found

Species richness, D, varied from 1 97 (PA 190 (RMD)) to 17.70 (PA 234 (RN1-RS2)), and corresponded closely to the number of taxa present Overall, species richness values were extremely variable, but indicated the presence of a high-quality and uniformly distributed estuarine infaunal community As with species abundance, richness values were generally highest in the lower Laguna Madre

Mean infaunal standing crop (wet weight biomass) varied significantly from 0 011 gm/0 023 m^2 at PA 221 (RMD) (one sample only) to 2 036 gm/0 023 m^2 at PA 236 (RN1-RS2) (Table 17). The high value at PA 236 (RN1-RS2) was attributed to one large mollusk Lower Laguna Madre stations generally had higher biomass levels than did stations in the upper Laguna Madre

Table 17 Benthic macroinfauna biomass for major taxonomic groups surveyed in Laguna Madre, Texas in September-October, 1996. Results are expressed as gm wet weight per 0 023 m^2.

STATION (BVA)	SITE/REP	ANNELIDA	CRUST.	MOLLUSCA	ECHINO.	MISC.	TOTAL
1	183A (N1-S2)	0.067	0 043	0.130	--	0 005	0 245
2	183A (RN1-RS2)	0 055	0 001	0 102	--	0 002	0 160
3	183A (MD1-MD2)	0 010	0 022	0 091	--	0	0 123
4	183A (RMD)	0 097	0	0 261	--	0	0 358
5	183B (N1-S2)	0 078	0 001	0 056	--	0.002	0 136
6	183B (RN1-RS2)	0.058	0	0 087	--	0.002	0 147
7	190 (N1-S2)	0 078	0 027	0 115	--	0	0.220
8	190 (RN1-RS2)	0 086	0 008	0.100	0.119	0	0 313
9	190 (MD1-MD2)	0 161	0 006	0 003	0.026	0.042	0 238
10	190 (RMD)	0 178	0 005	0 042	--	--	0.225
11	192 (N1-S2)	0 070	0 004	0 037	--	0.001	0.112
12	192 (RN1-RS2)	0 061	0 235	0.104	--	0 003	0.403
13	192 (MD1-MD2)	0 101	0	0.034	--	0 011	0.146
14	192 (RMD)	0 141	--	0 145	--	0	0.286
15	197 (N1-S2)	0 250	0 004	0 003	--	0 002	0 259
16	197 (RN1-RS2)	0 045	0 004	0 026	0 196	--	0 271
17	197 (MD1-MD2)	0 062	0 003	0 161	--	0 006	0 232
18	197 (RMD)	0 375	0 018	0 047	1 451	0	1 891
19	198 (N1-S2)	0 042	--	0 017	--	0 001	0 060
20	198 (RN1-RS2)	0.117	0.002	0.010	--	--	0.129
21	198 (MD1-MD2)	0.063	--	0 021	--	--	0.084
22	198 (RMD)	0 040	0 047	0 103	--	0 002	0 192
23	214 (N1-S2)	0 146	0.004	0 003	0 033	0 001	0 187
24	214 (RN1-RS2)	0 165	0 016	0 016	0 035	0.007	0 239
25	214 (MD1-MD2)	0 067	0	0 009	--	0.001	0 077
26	214 (RMD)	0 382	0 003	--	--	--	0 385
27	219 (N1-S2)	0 036	0 001	0 005	0 003	0 004	0 049
29	219 (RN1-RS2)	0 172	0 008	0 007	0 112	0 002	0 301
30	219 (MD1-MD2)	0 017	0	0 056	0 069	0 007	0 149
31	219 (RMD)	0 021	0	0 001	--	--	0 022
32	221 (N1-S2)	0.531	0 024	0 414	--	0 011	0 980
33	221 (RN1-RS2)	0.168	0.042	0.028	0.013	0 003	0.254
34	221 (MD1-MD2)	0.607	0.068	0.017	--	0 017	0.709
35	221 (RMD)	0 008	0 003	--	--	0	0.011
36	229 (N1-S2)	0 226	0.156	0 238	--	0	0.620
37	229 (RN1-RS2)	0 365	0 015	0 528	--	0	0.908
38	229 (MD1-MD2)	0.168	0 010	0 921	--	0.003	1.102
39	229 (RMD)	0 397	0.149	0 012	--	0 002	0 560
40	234 (N1-S2)	0 039	0 004	0 797	0 053	0 003	0 896
41	234 (RN1-RS2)	0 068	0.008	0 180	0 053	0 013	0.322
42	234 (MD1-MD2)	0.050	0.020	0 380	--	0 002	0 452
43	234 (RMD)	0 031	0.035	0 104	--	0 009	0 179
44	236 (N1-S2)	0 058	0.573	0.648	--	0 073	1 352
45	236 (RN1-RS2)	0 152	0 195	1.646	0.011	0.032	2.036
46	236 (MD1-MD2)	0 046	0 052	0 081	--	0	0.179
47	236 (RMD)	0 086	0 045	0 418	0 055	0 002	0 606

Note -- denotes no organisms were present; 0 denotes < 0.0006 gm

4.2 2.2 Numerical Classification Analysis

Normal (station) and inverse (species) classification analyses were performed on the Fall, 1996 data set and displayed as dendrograms (figures 20 and 21) Count data for the 67 species selected for analysis (31 polychaetes, 17 crustaceans, 16 mollusks, 1 oligochaete, 1 actiniarian, 1 rhynchocoel) were included in a matrix of station and species groups (Table 18) These taxa accounted for 93.7% of the macroinfaunal individuals collected (including certain indefinite taxa such as Oligochaeta [LPIL])

Numerical classification of survey stations was interpreted at an 8-group level (Figure 20) [Note that "M1-S2" and "RM1-RS2" in Figure 20 is equivalent to "N1-S2" and RN1-RS2", respectively, in the text and tables] These groups were delineated at a level of similarity from 27 to 73%, indicating a low degree of homogeneity among stations within groups Station Groups A, B, D and F were individual station groups containing PA 192 (MD1-MD2), PA 198 (MD1-MD2), PA 221 (RMD), and PA 234 (RMD), respectively. Two of these stations were single-sample stations (RMD) represented by low numbers of species and individuals. Groups A and B were comprised of 2-sample stations (MD1-MD2) Station Group C contained two stations and Station Group E contained eight stations Station Group G was very large, with 20 of the 47 stations. Station Group H contained 12 stations. The stations were grouped mainly according to placement area (except for the single-sample stations). Station Groups E and H contained primarily lower Laguna Madre stations: Station Group E included mainly stations in PAs 214, 219 and 221, while Station Group H comprised primarily stations in PAs 229, 234, and 236. Station Group G represented the remaining PAs, all of which were in the upper Laguna Madre Station groups did not correspond closely to sediment types, but in some cases did relate to presence/absence of seagrasses Group E stations contained no seagrasses, while Group H stations contained either *Halodule, Thalassia,* or *Syringodium* beds. However, Group G included both grassbed and non-grassbed stations PA 234 (RMD) was classified as station Group F This station was distinct from the other PA 234 stations (Group H), primarily as a result of its low species abundance and poor species representation in species Groups 4 and 5 Station groupings in the Fall were very similar to those in the Spring, indicating that no major habitat changes had occurred among the 47 stations since the Spring sampling.

In the report of the Spring sampling, it was stated "The fact that the RMD stations tended to separate from the other reference stations may indicate that nearness or farness from the GIWW plays a role in benthos composition However, only three of the MD1-MD2 stations tend to separate out...The other MD1-MD2 stations . are nestled in Station Groups D, F, or G " An examination of Figure 20 in this report, indicates that of the four 1-station Groups, two were RMDs and two were MD1-MD2s, while the only 2-station Group contained one of each type of station. Other RMDs are included in multi-station

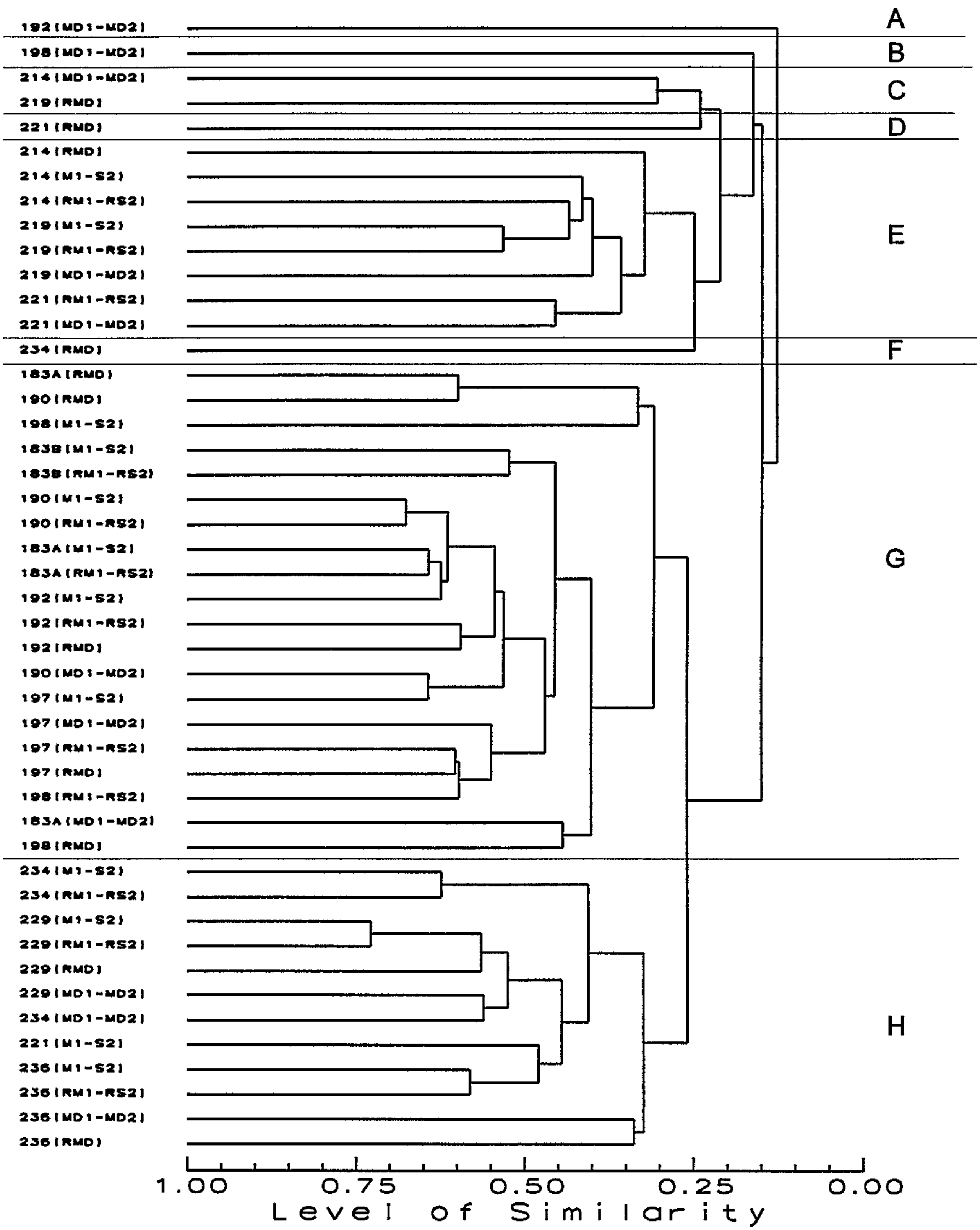


Figure 20 Normal (station) numerical classification analysis dendrogram for the Laguna Madre, Texas study, September - October , 1996.

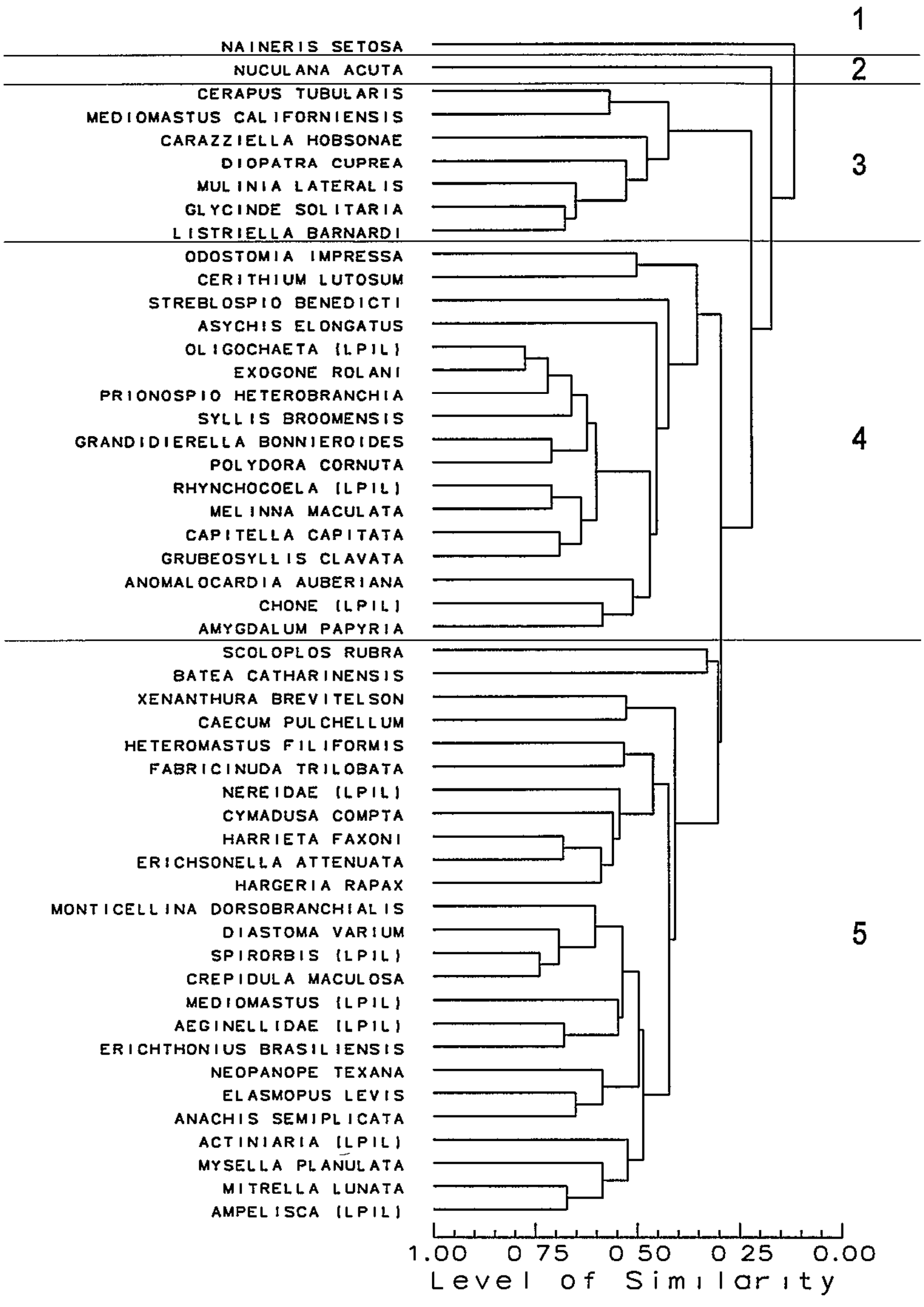


Figure 21 Inverse (species) numerical classification analysis dendrogram for Laguna Madre, Texas, September - October, 1996.

Table 18 Two-way matrix of station and species groups compiled from classification dendrograms for Laguna Madre, Texas, in September-October, 1996

	A	B	C		D	E								F	G							
	192 (MD1-MD2)	198 (MD1 MD2)	214 (MD1-MD2)	219 (RMD)	221 (RMD)	214 (RMD)	214 (N1-S2)	214 (RN1-RS2)	219 (N1-S2)	219 (RN1 RS2)	219 (MD1 MD2)	221 (RN1-RS2)	221 (MD1 MD2)	234 (RMD)	183A (RMD)	190 (RMD)	198 (N1-S2)	183B (N1 S2)	183B (RN1 RS2)	190 (N1-S2)	190 (RN1 RS2)	
Naineris setosa															26	21			2	38	10	1
Nuculana acuta														2								2
Cerapus tubularis			3	1	1		5	5	5	4			2									
Mediomastus californiensis					2		3		2			1										
Carazziella hobsonae			3				2			21	3	11	2	6								
Diopatra cuprea			1	5		1	2	3	9	13	1	10	10					1	1			3
Mulinia lateralis		1		1			4	13	19	12	18	1										
Glycinde solitaria				1			1	1	11	6	2	3	1	2								
Listriella barnardi						4	1	4	4	5	5	6	1	2								
Odostomia impressa															3			1	9	4	3	
Cerithium lutosum																		1	13	4		
Streblospio benedicti		1					7			1	1						37	6	2			
Asychis elongatus	24					3	1	23	2		1	3			2		4	39	7	1	30	
Oligochaeta (LPIL)		1					21	9	1	3	2	3	1		11	55	14	23	60	232	434	
Exogone rolani	1				1	4	6		3			11	3					1	29	48	68	
Prionospio heterobranchia								1	1			1	8			1		3	6	2	9	
Syllis broomensis					1							4			41	63			60	172	191	
Grandidierella bonnieroides	3											4					1	9	1	35	3	4
Polydora cornuta												1						22	3	78	20	
Rhynchocoela (LPIL)			2		1		2		4	3	3	15	6	1	1		2	14	11	24	7	
Melinna maculata			1			5	1	5	3	2		2	3		5		2	7	2	5	23	
Capitella capitata							7	2		2			6		1				1		6	
Grubeosyllis clavata							4												3	5		
Anomalocardia auberiana	3														5	12	10	2	3	13	11	
Chone (LPIL)					3	1				1		6							1	3	10	
Amygdalum papyria							1			1					1	1	1		1	4	9	
Scoloplos rubra	7				2			1				3					1	1	12			
Batea catharinensis												2	21									
Xenanthura brevitelson						1		2				7		2	10			23	43	2	22	
Caecum pulchellum										1		2	1					1		5	2	
Heteromastus filiformis																		1				
Fabricinuda trilobata																						
Nereidae (LPIL)						1	1			6	1	1									1	
Cymadusa compta												2										
Harrieta faxoni																		3		2		
Erichsonella attenuata																					2	
Hargeria rapax							4													1		
Monticellina dorsobranchialis					1							1										
Diastoma varium												1	5						2	6		
Spirorbis (LPIL)												1										5
Crepidula maculosa													1									
Mediomastus (LPIL)					6	3	13	2	15	7	2	65	5	6								
Aeginellidae (LPIL)					1	3	1		1	1		2	2									
Erichthonius brasiliensis			1	2	6	1	3	3	5	1			3									
Neopanope texana													2							1	1	
Elasmopus levis																						
Anachis semiplicata																						
Actiniaria (LPIL)	2							1		4		1	7	1								
Mysella planulata												1	3									
Mitrella lunata													1									
Ampelisca (LPIL)		1												1								

Table 18 Continued

	G													H											
	183A (N1-S2)	183A (RN1-RS2	192 (N1-S2)	192 (RN1-RS2)	192 (RMD)	190 (MD1-MD2)	197 (N1-S2)	197 (MD1-MD2)	197 (RN1 RS2)	197 (RMD)	198 (RN1-RS2)	183A (MD1-MD2	198 (RMD)	234 (N1-S2)	234 (RN1-RS2)	229 (N1-S2)	229 (RN1-RS2)	229 (RMD)	229 (MD1-MD2)	234 (MD1-MD2)	221 (N1-S2)	236 (N1-S2)	236 (RN1-RS2)	236 (MD1-MD2)	236 (RMD)
Nainerts setosa	2		16																						
Nuculana acuta														55	21					4					
Cerapus tubularis														1							109	2	1		
Mediomastus californiensis														6							37		2		
Carazziella hobsonae														8	26		7				3		12		11
Diopatra cuprea			2				1				1										11				
Mulinia lateralis														10	1						5				
Glycinde solitaria								1	1					12	1					1	8			3	
Listriella barnardi														8	7						1				
Odostomia impressa	31	6										25										33	1		2
Cerithium lutosum	7	12		2	2				2	1		8	1			6	27		9				1		
Streblospio benedicti		1	1	3			13	1	9	10	7			4	8	17	1	3			678	91	2	341	
Asychis elongatus	4	12		6		34	44	4	14	3						1	2			1	1				
Oligochaeta (LPIL)	173	32	278	325	169	32	289	16	132	62	20	4	16	9	13	186	128	74		88	4051	267	46	84	3
Exogone rolani	56	66	64	49	15	25	167	14	57	33	18	6	2	10	22	187	312	116	33	29	71	68	82	1	6
Prionospio heterobranchia	21	8	11	7	5	14	20	11	1	3	6			6	6	348	257	170	87	41	177	93	68	31	5
Syllis broomensis	178	81	132	35	33	6	3		16	4		74	95	6	12	48	39	29	42	22		2	17		3
Grandidierella bonnieroides	14	45	89	10		17	63	6	4	34	22		90		1	33	45	19	28	8	3	47	3	2	
Polydora cornuta	128	39	45	37	2	38	48	18	7	14	6	25	7			13	7	13			6				
Rhynchocoela (LPIL)	25	25	18	20	4	17	12	8	2	4	3	12	5	15	7	23	17	12	9	2	25	10	10		1
Melinna maculata	7	4	5	26	11	3	3	6	5		2	2		3	1	11	53	3	21	1	25		2		
Capitella capitata	40	1	6	2	2		27	5	2		2			3	1	79	47	18		1	37	16	10	27	
Grubeosyllis clavata	18	10	12	3	1	2	18	5	1	14		2	2	1	2	37	37	28	6	2	16	16	4		
Anomalocardia auberiana	94	6	26	63	19	1	3	18	4	1	10		4	1					1		1				
Chone (LPIL)	39	7	8	3	1	5	2			1	1		1		2	8	24	2	7	1	2		2		
Amygdalum papyria	12	3	3	4	1	3	5	1					1			1					1				
Scoloplos rubra		1		2		1	11	1							4					1	16		3		
Batea catharinensis																1					14		14		
Xenanthura brevitelson	14	37												23	6	7	3		34	2	9		10		
Caecum pulchellum	2	3		1										4	14	1	2		2	10	2		21		1
Heteromastus filiformis																129	173	7	1	2	44			1	
Fabricinuda trilobata												4				22	77	111	6	13		9	9		1
Nereidae (LPIL)	2			2	1		1	12						1	6	14	10	1	2	4	2	5	2		
Cymadusa compta			1	4		10	13			11				1	4	35	14	5	14	8	24	94	19		
Harrieta faxoni	3	1	2	1		2	2						3	2		11	16		3	2	13	21	4	1	
Erichsonella attenuata	5	4	5	3		1	3		1	1				1		9	21	1	2		6	6	1		
Hargeria rapax	1		1				1		1	2	1		4	1		14	3	9	3	2	3	2	3	1	1
Monticellina dorsobranchialis														15	16			1		4		298	54	2	31
Diastoma varium	1									1				15	21	23	157			14	52	47	158	12	32
Spirorbis (LPIL)														5	8	4	120	2	1	81	3	65	33	1	4
Crepidula maculosa														9	5	18	30	2	5	19	10		52	3	9
Mediomastus (LPIL)	1		1											37	63	36	113		11	9	271	36	219	15	
Aeginellidae (LPIL)								3						1	8	4	7			5	24	59	28	1	1
Erichthonius brasiliensis														3	4						22	51	20	1	2
Neopanope texana	1			1								1	1	1		4	1	2		1	3	15	13	1	1
Elasmopus levis														2	2	4		1		2	2	43	38		
Anachis semiplicata	3													3	7	1			3	3	2	12	6		3
Actiniaria (LPIL)		1				1								3	9				3	1	10	5	5	2	1
Mysella planulata														2	5	1	35				9		4		
Mitrella lunata															5	3	6	1	2	8	14	7	3		1
Ampelisca (LPIL)								1						4	3	1	7			5	13	4	1	1	

Groups but only PA 229 RMD is nestled in a Station Group. All of the others are at the extremities and are among the most dis-similar of the stations within the Station Group This is also true of MD1-MD2s stations from PAs 183A, 221, and 236 but the MD1-MD2s stations from PAs 190, 197, 229, and 234 are nestled in the Station Groups. Therefore, the Fall data tend to support the hypothesis that nearness or farness from the GIWW plays a role in benthos composition

Examples of the lack of difference between N1-S2 stations and RN1-RS2 stations, at a given PA, are provided by the most similar stations in Station Group E (PA 219), Station Group G (PAs 190, 183A, and 183B), and Station Group H (PAs 229, 234, and 236). For four others, the N1-S2 and RN1-RS2 stations are in the same subgroup of a Station Group (PA 214; PA 192, PA 197) or are in the same Station Group (PA 198) For only one PA were the N1-S2 and RN1-RS2 stations in separate Station Groups: PA 221, as it was in the Spring.

Classification of the 67 taxa was interpreted at a 5-group level (Figure 21) These groups were delineated at a 31% to 82% level of similarity, which indicated moderate heterogeneity among species groups Species Groups 1 and 2 each contained one species Species Group 3 contained seven species, including two crustaceans and four polychaetes Species Group 4 included 17 species, including ten polychaetes and four mollusks Species Group 5 contained 25 species, representing 11 crustaceans, seven mollusks, and seven polychaetes. The five most abundant taxa (Oligochaeta [LPIL], *Exogone rolani*, and *Prionospio heterobranchia*, *Syllis broomensis*, and *Streblaspio benedicti* were included in Species Group 4. Species groups contained different combinations of taxa in the Fall and Spring surveys, most likely because of generally low similarity levels for both surveys This suggests that habitat types are only moderately distinct.

4 2.2 3 Relationships Between Placement Area Habitats and Benthic Communities

As reported for the Spring 1996 survey and as noted above in the comparison of N1-S2 and RN1-RS2 stations for the various PAs, benthic assemblages in the September - October, 1996 Laguna Madre PAs exhibited minimal impacts from dredged material disposal practices Infaunal taxa and individual abundances varied primarily with PA location and presence/absence of grassbeds. Station and species groupings, generally reflected north-south trends, but these were not related to sediment texture.

As with the spring data, the possible impacts of dredged material disposal activities in the area were evaluated in regard to the number of years since the last disposal occurred in each Placement Area Table 19 summarizes the comparisons between PA and reference stations with respect to selected

Table 19 Comparisons between benthic macroinfaunal community parameters at reference stations versus disposal monitoring stations with respect to years since the placement areas were last used

Placement Area	No. Years Since Most Recent Disposal	DIFFERENCES BETWEEN REFERENCE AND DISPOSAL STATIONS			
		Total # Taxa	Total # Indiv.	Species Diversity	Pielou's Evenness
197	1	-7	523	-0.24	-0.03
198		10	32	0 77	0 09
214		2	17	-0 22	-0.07
219		4	12	0.09	-0 01
221		-46	-5873	1.72	0 47
234	2	11	76	0 10	0
190	7	-6	190	-0 30	-0.06
192		3	-70	-0 13	-0 04
229	9	13	464	0 23	0.03
236		45	-397	0.37	0 01
183A	13	-9	-489	0.16	0 08
183B		11	132	0.14	-0.03

Values are the mean parameter value at the PA reference stations, RN1-RS2, minus the mean value for the PA stations, N1-S2 MD and RMD stations are not included All means are presented in Table 4.

benthic macroinfaunal community parameters. In Table 19, the difference between community parameters at reference versus PA stations is negative when PA station values are higher In the Spring data, there appeared to be a trend toward higher parameter numbers in the PA stations versus the reference stations for recently-used PAs. However, the comparisons for the Fall data show no clear differences in benthic community statistics at PA and reference stations, with respect to either location (north-south trends) or elapsed time since the most recent dredging The infaunal assemblages censused during September - October, 1996 were generally less diverse and less abundant than during the Spring throughout the Laguna Madre. In addition, there were no patterns of sediment texture that would reflect impacts, from placement activities: sediment distributions - like infaunal communities appeared to vary independently of the location and age of previous dredged material placement, although there was a slight trend of decreasing sediment coarseness from north to south.

Composition of benthic assemblages reflected geographic rather than placement-related trends in Fall, 1996. Selected species censused in this survey were classified with respect to their status as indicators of one of the following three stages of community succession:

Group I	Opportunistic species prevalent during early succession,
Group II	Intermediate species found in mid-succession habitats,
Group III	Near-equilibrium species associated with relatively stable, less-disturbed habitats.

Table 20 summarizes the species associated with these groupings, which are very similar to groupings for the Spring, 1996 survey When these species groups were compared to the two-way matrix (Table 18), it was evident that succession Group I species were most prevalent in species Group 4, and further, that these taxa generally occurred at moderate to high abundance throughout the study area, and were most abundant at Group G and Group H stations, representing both Upper and Lower Laguna Madre PAs Succession Group II species were more ubiquitous and exhibited little correspondence with geographic location Succession Group III species, on the other hand, were most concentrated in species Groups 3 and 5, and were best represented at station Groups E and H, which included stations located in the Lower Laguna Madre. These patterns were very similar to those observed for the Spring, 1996 survey and indicated again that disposal practices have had little influence on the composition of the benthic communities in the Laguna Madre

Table 20. Benthic macroinfaunal indicator species found in Laguna Madre in September-October 1996, arranged according to habitat/stage groups

GROUP I (Opportunistic Species; Early Succession)
Mediomastus spp (P)
Prionospio heterobranchia (P)
Capitella capitata (P)
Heteromastus filiformis (P)
Polydora spp. (P)
Grandidierella bonnieroides
Bittium (Diastoma) varium (M)
Xenanthura brevitelson (C)
Mulinia lateralis (M)
GROUP II (Intermediate Species; Mid-Succession)
Melinna maculata (P)
Nuculana acuta (M)
Asychis elongatus (P)
Ampelisca spp (C)
Cerapus tubularis (C)
Hargeria rapax (C)
Fabricinuda trilobata (P)
Naineris setosa (P)
GROUP III (Near-Equilibrium Species; Stable Habitats)
Diopatra cuprea (P)
Amygdalum papyria (M)
Crepidula maculosa (M)
Caecum pulchellum (M)
Mitrella lunata (M)
Glycinde solitaria (P)
Scoloplos rubra (P)
Anachis semiplicata (M)
Listriella barnardi (C)

4.2.3 Additional Statistical Data Analyses

Following review of the draft Report and the conclusions drawn, the National Marine Fisheries Service requested that more extensive statistical analyses of the data be conducted than was possible under the original Scope of Work. This Section 4.2 3 discusses the results of the more extensive data analysis

The primary original questions posed in the Scope of Work for the Project can be stated· "At any given PA, is there any difference in the benthos or sediment that can be attributed to the placement of dredged material? If so, can this be related to time-since-disposal or the presence or absence of seagrass?" Sections 4.2.1 and 4 2.2 primarily utilize cluster analyses to determine the answer to these questions and concluded the following.

> Based on a comparison of N1-S2 and RN1-RS2 stations for the various PAs, "benthic assemblages in the Laguna Madre exhibited minimal impacts from dredged material placement practices [for the Spring data] Differences in infaunal taxa and individual abundances were related primarily to PA location and presence/absence of grassbeds" and
>
> benthic assemblages in the September - October, 1996 Laguna Madre PAs exhibited minimal impacts from dredged material disposal practices Infaunal taxa and individual abundances varied primarily with PA location and presence/absence of grassbeds. Station and species groupings, generally reflected north-south trends, but these were not related to sediment texture.

Additionally, direct statistical comparisons were made for each PA using the N1-S2 and RN1-RS2 stations as replicates and the Student's t-test to compare these two station sets at each PA for the number of individuals and the number of taxa (pages 42 and 56).

The results for the Spring sampling period yielded three sets of data (the number of taxa at PA198 ($\alpha = 0.036$) and the number of individuals at PAs 229 and 234 ($\alpha = 0\ 010$ and $0\ 047$, respectively) where there was a statistically significant difference, at the 95% confidence level, between N1-S2 means (17.2; 30,768, and 15,471, respectively) and RN1-RS2 means (4 7, 15,913, and 4,964, respectively)

With the exception of the preceding, the level of significance between N1-S2 and RN1-RS2 for these two parameters ranged from $\alpha = 0\ 062$ for the number of individuals at PA214 to 0.474 for the number of taxa at PA190 The average level of significance was $\alpha = 0\ 201$

The results for the Fall sampling period yielded only one set of data (the number of taxa at PA221) where there was a statistically significant difference between N1-S2 (mean = 42 7) and RN1-RS2 (mean = 15 8; $\alpha = 0.0002$). With the exception of the preceding, the level of significance between N1-S2 and RN1-RS2 for these two parameters ranged from $\alpha = 0.056$ for the number of individuals at PA221 to 0 469 for the number of individuals at PA219. The average level of significance was $\alpha = 0\ 282$ Based on these results for both the spring and fall data, it was concluded in the draft Report that there was no significant differences between PA stations and their respective reference stations.

However, for the draft Report, whether a PA was considered to be "seagrass" or "non-seagrass" was based on the original sampling plan, not the actual occurrence of seagrasses at the various PAs Therefore, the data were re-examined using the criteria of whether seagrasses were actually found at the stations to define the category of each station These categories were.

1 Seagrass or vegetated seagrasses were found at the RMD site, seagrasses were found at both MD1-MD2 sites; seagrasses were found at least five-of-six sites for Stations N1-S2 and RN1-RS2

2 Semi-vegetated seagrasses were found at one-of-two sites for Stations MD1-MD2, seagrasses were found at two- to four-of-six sites for Stations N1-S2 or RN1-RS2

3 Non-vegetated no seagrass at MD1-MD2; no seagrass at RMD, seagrass found at no more than one site for Stations N1-S2 and RN1-RS2

The following parameters were chosen for analysis (1) number of taxa per replicate, (2) overall density of the benthos (density), (3) H', (4) J', (5) D, (6) depth, (7) % sand, (8) density of Group I organisms (GI), (9) density of Group II organisms (GII), and (10) density of Group III organisms (GIII) The total number of taxa and the total number of individuals were not amenable to statistical comparison if the number of replicates (sites) or the size of the sampling device was different at one or more sites, so these two parameters were not used for statistical analysis Also, % sand was considered representative of grain size data so % silt and % clay were not used However, it was felt that the Group I (opportunistic species), II (intermediate species), and III (near-equilibrium species) organisms (Sections 4.2 1.3 and

4.2.2 3 in the May Report) could provide an interesting look at the data, so these were separated from the total group of organisms and compared separately Tables 21 and 22 present the stations in each category for the Spring and Fall data, respectively, and the data for each station

Based on the three categories and the ten parameters, there were 350 possible analyses for the spring data and 260 for the fall data. The reason for the disparity is the fact that the t-test could only be calculated if there were at least two entries in each category In the early portion of the analysis, all parameters for all categories were examined However, it was noted that, with the exception of "J'", significance was never found unless the mean difference between two categories was greater than 30%. Therefore, 30% was used as a cutoff value for all parameters except "J'" to reduce the number of analyses from the potential of 610. In all, 367 Student's t-tests were conducted to determine significance of the difference in the mean parameter values for the ten parameters and the three categories Tables 23 (Spring) and 24 (Fall) present the results of the statistical analyses In the discussion below, each set of statistical analyses of a suite of ten parameters is called a "comparison". To help explain the results of the analyses, the listing of comparisons is broken down three ways, "A" types of stations, "B" amount of seagrass at the various stations, and "C" Upper Laguna Madre vs Lower Laguna Madre

An examination of Tables 23 and 24, indicate that significant differences ($\alpha = 0.05$) were found for the parameters, listed below under "A", "B", and "C". For example, the first entry below, under "A", indicates that the Upper Laguna Madre seagrass stations, Spring data, included at least two N1-S2 stations and at least two RN1-RS2 stations and that when the statistical analyses were conducted, the mean values for depth and the densities of Group III organisms were significantly different between these two types of stations For the other parameters, the mean values were not significantly different There is no entry for the Fall data, Upper Laguna Madre, non-vegetated stations for the comparison of N1-S2 versus RN1-RS2 stations because there were not at least two N1-S2 stations and at least two RN1-RS2 stations for which data were available for Upper Laguna Madre, non-vegetated stations in the Fall and, therefore, the Student's t-test would not work.

A COMPARISON OF TYPES OF STATIONS

N1-S2 versus RN1-RS2	**Parameters with significant differences between the means**
Spring data, Upper Laguna, seagrass stations	depth, GIII
Fall data, Upper Laguna, seagrass stations	depth, GI

Spring data, Upper Laguna, non-vegetated stations	none
Spring data, Lower Laguna, seagrass stations	% sand
Spring data, Lower Laguna, non-vegetated stations	none
Fall data, Lower Laguna, non-vegetated stations	none
MD1-MD2 versus RMD	
Spring data, Upper Laguna, seagrass stations	none
Spring data, Lower Laguna, non-vegetated stations	density
Fall data, Lower Laguna, non-vegetated stations	% sand
Fall data, Lower Laguna, seagrass stations	none
N1-S2 versus MD1-MD2	
Spring data, Upper Laguna, seagrass stations	D
Spring data, Upper Laguna, non-vegetated stations	D
Fall data, Upper Laguna, non-vegetated stations	none
Fall data, Lower Laguna, seagrass stations	D
Spring data, Lower Laguna, non-vegetated stations	none
Fall data, Lower Laguna, non-vegetated stations	none
RN1-RS2 versus RMD	**Parameters with significant differences between the means**
Spring data, Upper Laguna, seagrass stations	density, D
Fall data, Upper Laguna, seagrass stations	density, D
Spring data, Lower Laguna, seagrass stations	taxa, density, D, GIII
Spring data, Lower Laguna, non-vegetated stations	D

Fall data, Lower Laguna, non-vegetated stations	H', D

These data indicate that there are few differences between Stations N1-S2 and RN1-RS2, confirming the conclusions in the draft Report(Section 4.2.2.2) based on cluster analyses.

There was only one instance where there was a significant difference in grain size between N1-S2 stations and RN1-RS2 stations, also supporting the grain size observations made in the draft Report There are also few differences between Stations MD1-MD2 and RMD, or between N1-S2 and MD1-MD2, although there was a significant difference in mean "D" values for three of the six comparisons. The only stations with any consistent differences are RN1-RS2 versus RMD (density at three of five comparisons and D at five of 6 comparisons). This tends to support the conclusion presented on page ?? on the draft report that "the RMD stations tended to separate from the other reference stations [which] may indicate that nearness or farness from the GIWW plays a role in benthos composition" and on page 60, "Therefore, the Fall data tend to support the hypothesis that nearness or farness from the GIWW plays a role in benthos composition."

Another way of examining the results of the statistical analyses is to examine the number of "hits" that occurs for a particular type of examination. For example, as was noted above, each comparison actually represents the statistical comparison of the means of ten parameters. Therefore, each comparison allows the opportunity for ten instances of statistical significance and there was no parameter for which a significant difference was not observed in at least one comparison In the case of N1-S2 versus RN1-RS2 comparisons, there were six data sets that were amenable to analysis and, therefore, the opportunity for 60 instances of significant difference ("hits") Of these, sixty opportunities, there were only five, or 8 3%, "hits" The MD1-MD2 vs RMD station comparisons and N1-S2 vs MD1-MD2 station comparisons, only had 5.0% "hits" each The RN1-RN2 vs RMD station comparisons, on the other hand, had 22% "hits"

B COMPARISONS BASED ON AMOUNT OF VEGETATION

Seagrass versus semi-vegetated	**Parameters with significant differences between the means**
Spring data, Upper Laguna, all stations	taxa, density, GI
Fall data, Upper Laguna, all stations	density, GII
Spring data, Upper Laguna, N1-S2	taxa, D, depth, GIII

Spring data, Lower Laguna, all stations	% sand
Fall data, Lower Laguna, all stations	none
Spring data, Lower Laguna, N1-S2	none
Fall data, Upper Laguna, RN1-RS2	density
Seagrass versus non-vegetated	
Spring data, Upper Laguna, all stations	density, J', depth, GI
Fall data, Upper Laguna, all stations	taxa, density, D, depth, GI
Spring data, Upper Laguna, N1-S2	density, depth
Fall data, Upper Laguna, N1-S2	density, GI, GIII
Spring data, Upper Laguna, MD1-MD2	% sand, GI, GIII
Spring data, Upper Laguna, RN1-RS2	density, depth, GI
Spring data, Lower Laguna, all stations	% sand
Fall data, Lower Laguna, all stations	taxa, density, depth, % sand, GI
Spring data, Lower Laguna, N1-S2	taxa, depth
Fall data, Lower Laguna, N1-S2	taxa, J', D, depth, GI
Fall data, Lower Laguna, MD1-MD2	depth
Spring data, Lower Laguna, RN1-RS2	taxa, density, % sand, GIII
Spring data, Lower Laguna, RMD	% sand
Fall data, Lower Laguna, RMD	taxa, % sand
Semi-vegetated versus non-vegetated	
Spring data, Lower Laguna, N1-S2	depth, GI
Fall data, Upper Laguna, all stations	taxa, D, GI

There is a significant difference between the means of more parameters when the amount of seagrass at stations are compared, as opposed to the locations of the stations in or out of PAs For example, the seagrass vs semi-vegetated station comparisons yielded 15 7% "hits", the seagrass vs non-vegetated station comparisons yielded 29.3% "hits", and semi-vegetated vs non-vegetated station comparisons yielded 25% "hits"

There was not much consistency in the seagrass vs semi-vegetated station comparisons with density being significant in three of the seven comparisons and taxa in two As is not surprising, depth was significantly difference in eight of the 14 data sets amenable to analysis in the seagrass vs non-vegetated station comparisons, followed by 7 "hits" for overall density and density of Group I organisms, and 6 "hits" for number of taxa per replicate and "D" The mean density of Group I organisms was significantly different for both of the semi-vegetated vs non-vegetated station comparisons, but the database is small Overall, however, when non-vegetated stations are compared to stations with any amount of vegetation, the mean density of Group I organisms (opportunistic benthos) was significantly different for over half (9 of 16) of the comparisons

In general, these amount-of-vegetation comparisons, when compared to the location-of-stations-relative-to-PAs comparisons, support the conclusions of the draft Report, noted at the beginning of this Section 2.4 3.

C COMPARISONS BASED ON STATION LOCATION IN UPPER OR LOWER LAGUNA MADRE

Upper vs Lower	**Parameters with significant differences between the means**
Spring Data, all seagrass stations	taxa, D, % sand, GI, GIII
Fall Data, all seagrass stations	taxa, H', D, % sand, GI, GIII
Spring Data, N1-S2 seagrass stations	taxa, D, % sand, GIII
Fall Data, N1-S2 seagrass stations	taxa, D, GI, GIII
Spring Data, RN1-RS2 seagrass stations	taxa, % sand, GIII
Spring Data, RMD seagrass stations	density, GI
Fall Data, RMD seagrass stations	taxa, H', D, % sand

Spring Data, all semi-vegetated stations	taxa, H', D, GIII
Fall Data, all semi-vegetated stations	taxa, % sand, GIII
Spring Data, N1-S2 semi-vegetated stations	H', D, GIII
Spring Data, all non-vegetated stations	taxa, density, D, % sand, GII
Fall Data, all non-vegetated stations	taxa, H', D, depth, GIII
Spring Data, N1-S2 non-vegetated stations	taxa, density
Fall Data, N1-S2 non-vegetated stations	H', D
Spring Data, RN1-RS2 non-vegetated stations	H', D, GIII
Spring Data, MD1-MD2 non-vegetated stations	density, GII
Fall Data, MD1-MD2 non-vegetated stations	H'

The results presented for the Upper Laguna Madre vs Lower Laguna Madre yields 34.1% "hits", and if only the "all seagrass station" comparisons are examined, there are 55% hits, with the number of taxa per replicate, D, % sand, and the density of Group I and Group III organisms being generally included for both the Spring and Fall data and H' being generally included for the Fall data. Overall, for the 17 Upper Laguna Madre vs Lower Laguna Madre comparisons, the number of taxa per replicate and D were significantly different in 11 comparisons, followed by the density of Group III organisms in 10, H' in 8, and % sand in 7. It is interesting that in the comparison of the Upper and Lower Laguna Madre stations ("C"), the density of the near-equilibrium, Group III organisms, was significantly different in a majority of the comparisons whereas in the comparison of amount of vegetation at stations ("B"), the density of the opportunistic Group I organisms was significantly different in a majority of the comparisons and Group I density was consistently higher in seagrass stations than in non-vegetated stations.

In general the results of the Upper vs Lower Laguna Madre comparisons tend to support the conclusions of the draft Report:

> Composition of benthic assemblages reflected geographic rather than placement-related trends in Fall, 1996. These patterns were very similar to those observed for the Spring, 1996 survey and indicated again that disposal practices have had little influence on the composition of the benthic communities in the Laguna Madre.

All of the additional statistical analysis tends to support the general conclusion of the draft Report

> few clear distinctions exist in sediment texture or benthic macroinfauna, that would indicate habitat differences caused by placement practices [for the Spring data]
>
> . the comparisons for the Fall data show no clear differences in benthic community statistics at PA and reference stations, with respect to either location (north-south trends) or elapsed time since the most recent dredging. In addition, there were no patterns of sediment texture that would reflect impacts, from placement activities sediment distributions - like infaunal communities appeared to vary independently of the location and age of previous dredged material placement, although there was a slight trend of decreasing sediment coarseness from north to south.

4 3 CONCLUSION

The questions raised in the National Marine Fisheries letter are very pertinent, and pointed to a problem with the original Scope of Work and carried into the draft Report which could have been substantial, *i e* that PAs defined as seagrass areas were not necessarily vegetated and some that were defined to be non-vegetated did, in fact, contain seagrass However, the overall conclusions reached in Sections 2 4 1 and 2 4 2 are generally the same as those determined by additional and different analyses of the benthos and grain size data, as discussed in Section 2 4 3

5.0 SUMMARY

Benthic macroinfaunal community composition was monitored in Laguna Madre, Texas in conjunction with evaluation of environmental impacts of the historic practice of open-water placement of dredged material The objectives of the survey were to describe benthic community composition, and to quantify basic community characteristics such as species and individual abundance, diversity, and evenness Infaunal and sediment data were to be used to determine whether the placement of dredged material had an adverse impact on the benthic resources of Laguna Madre.

The purpose of this study was to characterize the benthic community, at two different times of the year, in and near PAs in the Upper and Lower Laguna Madre and at reference sites across the GIWW from the selected PAs. The PAs were selected to depict (1) heavy, moderate, and light usage and (2) deep, non-vegetated and shallow, vegetated habitats.

Six PAs were selected in both the Upper and Lower Laguna Madre by EH&A, the U S Army Corps of Engineers (USACE) and the National Marine Fisheries Service (NMFS) personnel The following PAs were selected:

	Upper Laguna	Lower Laguna
Low-Use Vegetated	PA183A	PA229
Low-Use Unvegetated	PA183B	PA236
Medium-Use Vegetated	PA190	PA214
Medium-Use Unvegetated	PA192	PA219
High-Use Vegetated	PA197	PA221
High-Use Unvegetated	PA198	PA234

Note that PA183 was used both as the vegetated and unvegetated PA for Low Use in the Upper Laguna Madre

The Scope of Work noted that in each PA, two randomly-selected stations were to be occupied in the northern third of the PA (Stations N1 and N2), the middle third (Stations M1 and M2), and the southern third (Stations S1 and S2) Additionally, two stations parallel to the longitudinal axis, north and south of the north-south midpoint were to be occupied for each PA, at 250 feet, or more, from the non-GIWW edge of the PA (Stations MD1 and MD2) Seven reference stations were to be located directly across, and at roughly the same distance from, the GIWW as the PA stations (RN1, RN2, RM1, RM2, RS1, RS2, and RMD)

At each station, one grab was taken for benthos analysis and one for grain size analysis Standard parameters which influence the benthic community structure, e g., temperature, salinity, pH, dissolved oxygen, Secchi depth, and water depth, were taken at each PA

For the Spring sampling, benthic samples were collected at 47 stations arranged within 11 PAs during the period of May 14 - May 30, 1996 (Figures 4 - 10, Tables 1 and 2) A total of 178 macroinfauna and sediment texture samples was collected, primarily using an Ekman grab with a surface area of 0 023 m^2 In some areas where the Ekman grab could not penetrate the bottom, other devices were used, including a post-hole digger The sample sizes with these alternative methods were different than the Ekman grab size, and ranged from 0 014 m^2 to 0 047 m^2 However, for data analysis, all samples were standardized to 0.047 m^2.

For the Fall sampling, benthic samples were collected at 49 stations during the period of September 23 - October 3, 1996 (Figures 11-17) In all, 177 macroinfauna and sediment texture samples were collected, almost exclusively with a post-hole digger (0.014 m^2 area). The Ekman grab was used at Placement Area 219, Station N1 because the water was too deep for the post-hole digger In the Spring sampling, several sampling techniques had been used In an attempt to standardize the sample size, the post-hole digger was used as the sampler of choice in the Fall

5 1 GRAIN-SIZE DATA

Sediments collected in the Spring at stations within the PAs (N1-S2) were similar in most cases to sediments at reference stations (RN1-RS2) However, relatively low percent sand was observed at stations within PAs 197, 234, and 236, indicating that past placement practices may have resulted in changes from predominantly sand habitats to mostly silt-clay habitats In contrast, the reference stations at PA 198 were considerably finer than the PA and near-PA stations.

Sediments in Fall were generally similar to those sampled in the Spring, except that the upper Laguna Madre stations contained slightly higher amounts of sand during the Fall survey. None of the upper Laguna PA sediments contained gravel (shell hash), all 14 stations where gravel was reported were in the lower Laguna Madre

As during the Spring survey, sediments at stations within the PAs were similar in most cases to sediments at reference stations. The relatively low percent sand observed at stations within PAs 197, 234, and 236, as noted above, was only still true at PAs 234 and 236 At PA 234, the difference in grain size between N1-S2 and RN1-RS2 was not as great in the Fall as it was in the Spring For PA 236, the difference in grain size was still dramatic Also in contrast to the Spring, PA 198 did not show the marked increase in sand from reference to PA and near-PA stations

5 2 BENTHOS

5.2 1 <u>Spring</u>

A total of 92,649 individuals (standardized to the number per 0 047 m²) representing 396 taxa was identified from 178 discrete samples Polychaetes comprised the majority of individuals and the greatest number of taxa. The most abundant species-level taxon collected was the polychaete *Prionospio heterobranchia* The second most abundant species was the amphipod *Ampelisca abdita*. Oligochaeta (LPIL) comprised 13 4% of all individuals, but probably included more than one species The taxon with the highest frequency occurrence was the polychaete, *Melinna maculata,* which was present at 42 of the 47 stations.

Community statistics by station reflect a high degree of dissimilarity between PAs, but moderate similarity between stations in the various PAs. Numerical classification of survey stations was interpreted at an 8-group level (Figure 18) These groups were delineated at a level of similarity from 35 to 75%, indicating a low degree of homogeneity among stations within groups

Four of the Station Groups (A, B, C, H) contained only individual stations, one (E) contained two stations, one (D) contained eight stations, one (G) contained nine stations, and the last Station Group (F) was very large, with 24 of the 47 stations All four of the single-station Station Groups, represented by low numbers of species and individuals, were RMD stations Within the Station Groups, the stations were grouped mainly according to PA (except for the single-sample stations) Station Groups D and G included mainly lower Laguna stations: Station Group D contained primarily PAs 214 and 219, while Group G was comprised primarily of stations in PAs 229 and 236. Station Group F represented the remaining PAs, all in the upper Laguna except for Station 46 (PA 229, RMD). Station 46 (PA 229, RMD) is the most dissimilar of the stations included in Station Group F and Station 36 (PA 219, RMD) is the most dissimilar of the stations included in Station Group D Station Groups did not correspond closely to sediment types, but in some cases did relate to presence/absence of seagrasses Group D stations contained no seagrasses, while Group G stations contained either *Halodule, Thalassia,* or *Syringodium* beds However, Group F included both grassbed and non-grassbed stations. The fact that the RMD stations tended to separate from the other reference stations may indicate that nearness or farness from the GIWW plays a role in benthos composition However, only three of the MD1-MD2 stations tended to separate out The other eight MD1-MD2 stations (Stations 5, 12, 19, 23, 27, 31, 35, and 45) were nestled in Station Groups D, F, or G

The lack of difference between N1-S2 stations and RN1-RS2 stations, at a given PA, is exemplified by the fact that the most similar stations in Station Groups D, F, and G are the N1-S2 and RN1-RS2 stations for the respective PAs. For six other PAs, the N1-S2 and RN1-RS2 stations are in the same subgroup of a Station Group or are in the same Station Group. For only two PAs were the N1-S2 and RN1-RS2 stations in separate Station Groups

Classification of the 61 taxa was interpreted at a 4-group level (Figure 19). These groups were delineated at a 33% to 87% level of similarity, which indicated moderate heterogeneity among species groups Species Group 1 contained two species of crustaceans (*Corophium louisianum* and *Melita* [LPIL]). Species Group 2 contained 11 species, including four crustaceans and six polychaetes Species Group 3 included 16 species, including five crustaceans and six mollusks Species Group 4 contained 32 species, representing 10 crustaceans and 14 polychaetes The most abundant taxa (Oligochaeta [LPIL] and *Prionospio heterobranchia*) were included in Species Group 4

Dredged material placement activities in the area date back to at least 1950, with the most recent dredging and placement occurring in 1995-1996. When selected benthic macroinfaunal community parameters were compared, it appears that most stations within PAs contained more abundant and diverse macroinfauna than do adjacent reference stations for the most recent placements (Table 12). Five of six sites where dredged material was placed two years prior to the May 1996 benthic collection exhibited higher numbers of species, individuals, diversity, and evenness PA 219, where reference station benthos were more abundant that benthos at stations within the PA, was the only recently used PA where the sediment texture within a PA exhibited a significant shift from sand to clay The high proportion of clay at the stations in the PA could have produced lower infaunal abundances Older PAs generally contained less abundant and diverse benthos. PAs used as much as 13 years prior to May 1996 (i e , PAs 183A and 183B) contained similar sediments at the reference and within-PA stations, reference station benthos in PA 183A (which contained seagrasses) were richer than PA-station benthos In PA 183B stations (unvegetated), the benthos were more abundant within the PA than at the reference stations

Composition of benthic assemblages reflected geographic rather than placement-related trends Species censused in the May 1996 survey were classified with respect to their status as indicators of one of the following three stages of community succession.

Group I	Opportunistic species prevalent during early succession,
Group II	Intermediate species found in mid-succession habitats;
Group III	Near-equilibrium species associated with relatively stable, less-disturbed habitats.

When these species groups were compared to the two-way matrix, it was evident that succession Group I species were most prevalent in species Group 4, and further, that these taxa generally were most abundant at stations sampled in the Upper Laguna Madre. Succession Group II species were more ubiquitous and exhibited little correspondence with geographic location Succession Group III species, on the other hand, were most concentrated in species Groups 2 and 3, and were best represented at station Groups D and G, which included stations in the Lower Laguna Madre Dredged material placement timing was similar in the Upper and Lower Laguna Madre, and few clear distinctions exist in sediment texture or benthic macroinfauna, that would indicate habitat differences caused by placement practices.

The results of direct statistical comparisons using each site in the N1-S2 and RN1-RS2 stations as a replicate and the Student's t-test to compare these two station-sets at each PA for the number of individuals and the number of taxa for the Spring sampling period yielded only three sets of data (the number of taxa at PA198 and the number of individuals at PAs 229 and 234 where there was a statistically significant difference between the PA station (N1-S2) and the reference stations (RN1-RS2)

5 2.2 Fall

A total of 26,015 individuals representing 308 taxa was identified from 177 discrete samples This was roughly two-thirds the abundance observed in the Spring survey, and represented a decrease that is typical for the Fall season in the northern Gulf of Mexico region Polychaetes comprised the majority of individuals and the greatest number of taxa. The most abundant species-level taxon collected was the polychaete *Exogone rolani*. The second most abundant species was the polychaete *Prionospio heterobranchia* Oligochaeta (LPIL) comprised 28 3% of all individuals, but probably included more than one species The taxon with the highest frequency occurrence was *Exogone rolani*, which was present at 36 of the 49 stations This species was not identified during the May survey, possibly because new literature became available to distinguish this species from *E. dispar*, which was numerically dominant in the previous survey. Both *E rolani* and *E dispar* were found in the Fall samples

Community statistics by station reflect a high degree of dissimilarity between PAs, but moderate similarity between stations in and near the various PAs. Excluding single-sample stations, the number of species censussed was generally higher in the lower Laguna Madre than in the upper Laguna Madre, during Fall 1996. This trend was also observed during the Spring 1996 survey, but was less distinct Statistical comparison of taxa numbers by station determined that species abundance during the Fall was significantly lower than during the Spring, 1996 ($\alpha < 0\ 001$)

Comparison of stations within the disposal areas with reference stations indicated that reference stations had much lower densities (and lower numbers of species) at PAs 183A, 197, and 221, although differences in number of individuals and number of taxa were only significant ($\alpha = 0\ 05$) at PA 221 At PA 236, individual abundances were similar, but species abundance was much higher at the reference station, although not statistically significant Species abundances at the reference stations were higher at eight of the 12 PAs, although not statistically significant. ??These comparisons were different from those observed for the Spring 1996 survey, when reference and disposal area stations were more similar ???

PA and reference stations within study area were not notably different with respect to species diversity, except that reference stations at PAs 198, 221, and 236 had much higher diversities than did the PA stations During the Spring 1996 survey, the PA 198 reference station diversity was much lower than the PA station, due to a lower number of species In the Fall 1996 survey, the biggest difference in diversities occurred at PA 221, and was attributed to extreme numerical dominance of Oligochaeta (LPIL) and to lower species abundance at PA 221 (N1-S2) When all stations were compared statistically, it was determined that species diversity was significantly lower in the Fall than in the Spring, 1996 ($\alpha < 0\ 005$) .

Overall, species richness values were extremely variable, but indicated the presence of a high-quality and uniformly distributed estuarine infaunal community As with species abundance, richness values were generally highest in the lower Laguna Madre Lower Laguna Madre stations generally had higher biomass levels than did stations in the upper Laguna Madre.

Numerical classification of survey stations was interpreted at an 8-group level (Figure 20) These groups were delineated at a level of similarity from 27 to 73%, indicating a low degree of homogeneity among stations within groups Station Groups A, B, D and F were individual station groups, either MD1-MD2 or RMD stations. Station Group C contained two stations, Station Group E contained eight stations, and Station Group H contained 12 stations Station Group G was very large, with 20 of the 47 stations The stations were grouped mainly according to placement area (except for the single-sample stations). Station Groups E and H contained primarily lower Laguna Madre stations Station Group E included mainly stations in PAs 214, 219 and 221, while Station Group H comprised primarily stations in PAs 229, 234, and 236. Station Group G represented the remaining PAs, all of which were in the upper Laguna Madre Station groups did not correspond closely to sediment types, but in some cases did relate to presence/absence of seagrasses· Group E stations contained no seagrasses, while Group H stations contained either *Halodule, Thalassia,* or *Syringodium* beds However, Group G included both grassbed and non-grassbed stations Station groupings in the Fall were very similar to those in the Spring, indicating that no major habitat changes had occurred among the 47 stations since the Spring sampling

In the report of the Spring sampling, it was stated "The fact that the RMD stations tended to separate from the other reference stations may indicate that nearness or farness from the GIWW plays a role in benthos composition However, only three of the MD1-MD2 stations tend to separate out...The other MD1-MD2 stations ..are nestled in Station Groups D, F, or G " An examination of Figure 20 in this report, indicates that of the four 1-station Groups, two were RMDs and two were MD1-MD2s, while the only 2-station Group contained one of each type of station Other RMDs are included in multi-station Groups but only PA 229 RMD is nestled in a Station Group All of the others are at the extremities and are among the most dis-similar of the stations within the Station Group. This is also true of MD1-MD2s stations from PAs 183A, 221, and 236 but the MD1-MD2s stations from PAs 190, 197, 229, and 234 are nestled in the Station Groups Therefore, the Fall data tend to support the hypothesis that nearness or farness from the GIWW plays a role in benthos composition

Examples of the lack of difference between N1-S2 stations and RN1-RS2 stations, at a given PA, are provided by the most similar stations in Station Group E (PA 219), Station Group G (PAs 190, 183A, and 183B), and Station Group H (PAs 229, 234, and 236) For four others, the N1-S2 and RN1-RS2 stations are in the same subgroup of a Station Group (PA 214, PA 192, PA 197) or are in the same Station Group (PA 198) For only one PA were the N1-S2 and RN1-RS2 stations in separate Station Groups PA 221, as it was in the Spring

Classification of the 67 taxa was interpreted at a 5-group level (Figure 21) These groups were delineated at a 31% to 82% level of similarity, which indicated moderate heterogeneity among species groups Species groups contained different combinations of taxa in the Fall and Spring surveys, most likely because of generally low similarity levels for both surveys. This suggests that habitat types are only moderately distinct

As reported for the Spring 1996 survey and as noted above in the comparison of N1-S2 and RN1-RS2 stations for the various PAs, benthic assemblages in the September - October, 1996 Laguna Madre PAs exhibited minimal impacts from dredged material disposal practices. Infaunal taxa and individual abundances varied primarily with PA location and presence/absence of grassbeds Station and species groupings, generally reflected north-south trends, but these were not related to sediment texture

In the Spring data, there appeared to be a trend toward higher parameter numbers in the PA stations versus the reference stations for recently-used PAs. However, the comparisons for the Fall data show no clear differences in benthic community statistics at PA and reference stations, with respect to either location (north-south trends) or elapsed time since the most recent dredging The infaunal assemblages censussed during September - October, 1996 were generally less diverse and less abundant than during the Spring throughout the Laguna Madre In addition, there were no patterns of sediment texture that would reflect impacts, from placement activities sediment distributions - like infaunal communities appeared to vary independently of the location and age of previous dredged material placement, although there was a slight trend of decreasing sediment coarseness from north to south.

Composition of benthic assemblages reflected geographic rather than placement-related trends in Fall, 1996. The species associated with the species-succession groupings are very similar to groupings for the Spring, 1996 survey When these species groups were compared to the two-way matrix, it was evident that succession Group I species were most prevalent in species Group 4, and further, that these taxa generally occurred at moderate to high abundance throughout the study area, and were most abundant at Group G and Group H stations, representing both Upper and Lower Laguna Madre PAs. Succession Group II species were more ubiquitous and exhibited little correspondence with geographic location Succession Group III species, on the other hand, were most concentrated in species Groups 3 and 5, and were best represented at station Groups E and H, which included stations located in the Lower Laguna Madre These patterns were very similar to those observed for the Spring, 1996 survey and indicated again that disposal practices have had little influence on the composition of the benthic communities in the Laguna Madre

The results of direct statistical comparisons using each site in the N1-S2 and RN1-RS2 stations as a replicate and the Student's t-test to compare these two station-sets at each PA for the number of individuals and the number of taxa for the Fall sampling period yielded only one set of data (the number of taxa at PA221) where there was a statistically significant difference between N1-S2 and RN1-RS2. Based on these results for both the spring and fall data, it was concluded in the draft Report that there was no significant differences between PA stations and their respective reference stations

5.2.3 Additional Statistical Data Analyses

Based on a review of the draft report, the data were re-examined using the criteria of whether seagrasses were actually found at the stations to define the category of each station These categories were seagrass or vegetated, semi-vegetated, or non-vegetated The following parameters were chosen for analysis (1) number of taxa per replicate, (2) overall density of the benthos (density), (3) H', (4) J', (5) D, (6) depth, (7) % sand, (8) density of Group I organisms (GI), (9) density of Group II organisms (GII), and (10) density of Group III organisms (GIII).

The listing of comparisons is broken down three ways, by types of stations, by the amount of seagrass at the various stations, and Upper Laguna Madre vs Lower Laguna Madre, to try to help explain the results of the analyses

Examining the data by station type, there was only one instance where there was a significant difference in grain size between N1-S2 stations and RN1-RS2 stations, also supporting the grain size observations made in the draft Report. There are also few differences between Stations MD1-MD2 and RMD, or between N1-S2 and MD1-MD2, although there was a significant difference in mean "D" values for three of the six comparisons The only stations with any consistent differences are RN1-RS2 versus RMD (density at three of five comparisons and D at five of 6 comparisons) These data indicate that there are few differences between Stations N1-S2 and RN1-RS2, confirming the conclusions in the draft Report

Another way of examining the results of the statistical analyses is to examine the number of "hits" that occurs for a particular type of examination For example, as was noted above, each comparison actually represents the statistical analysis of the means of ten parameters Therefore, each comparison allows the opportunity for ten instances of statistical significance and there was no parameter for which a significant difference was not observed in at least one comparison In the case of N1-S2 versus RN1-RS2 comparisons, there were six data sets that were amenable to analysis and, therefore, the opportunity for 60 instances of significant difference ("hits") Of these, sixty opportunities, there were only five, or 8 3%, "hits" The MD1-MD2 vs RMD station comparisons and N1-S2 vs MD1-MD2 station comparisons, only had 5 0% "hits" each The RN1-RN2 vs RMD station comparisons, on the other hand, had 22% "hits"

There is a significant difference between the means of more parameters when the amount of seagrass at stations are compared, as opposed to the locations of the stations in or out of PAs For example, the seagrass vs semi-vegetated station comparisons yielded 15 7% "hits", the seagrass vs non-vegetated station comparisons yielded 29 3% "hits", and semi-vegetated vs non-vegetated station comparisons yielded 25% "hits".

There was not much consistency in the seagrass vs semi-vegetated station comparisons with density being significant in three of the comparisons and taxa in two As is not surprising, depth was significantly difference in eight of the 14 data sets amenable to analysis in the seagrass vs non-vegetated station comparisons, followed by 7 "hits" for overall density and density of Group I organisms, and 6 "hits" for number of taxa per replicate and "D" The mean density of Group I organisms was significantly different for both of the semi-vegetated vs non-vegetated station comparisons, but the database is small. Overall, however, when non-vegetated stations are compared to stations with any amount of vegetation, the mean density of Group I organisms (opportunistic benthos) was significantly different over half (9 of 16) of the comparisons

In general, these amount-of-vegetation comparisons, when compared to the location-of-stations-relative-to-PAs comparisons, support the conclusions of the draft Report

The results presented for the Upper Laguna Madre vs Lower Laguna Madre yields 34.1% "hits", and if only the "all seagrass station" comparisons are examined, there are 55% hits, with the number of taxa per replicate, D, % sand, and the density of Group I and Group III organisms being generally included for both the Spring and Fall data and H' being generally included for the Fall data Overall, for the 17 Upper Laguna Madre vs Lower Laguna Madre comparisons, the number of taxa per replicate and D were significantly different in 11 comparisons, followed by the density of Group III organisms in 10, H' in 8, and % sand in 7. It is interesting that in the comparison of the Upper and Lower Laguna Madre stations ("C"), the density of the near-equilibrium, Group III organisms, was significantly different in a majority of the comparisons whereas in the comparison of amount of vegetation at stations ("B"), the density of the opportunistic Group I organisms was significantly different in a majority of the comparisons and Group I density was consistently higher in seagrass stations than in non-vegetated stations

In general the results of the Upper vs Lower Laguna Madre comparisons tend to support the conclusions of the draft Report

Composition of benthic assemblages reflected geographic rather than placement-related trends in Fall, 1996. These patterns were very similar to those observed for the Spring, 1996 survey and indicated again that disposal practices have had little influence on the composition of the benthic communities in the Laguna Madre.

All of the additional statistical analysis tends to support the general conclusion of the draft Report

.. few clear distinctions exist in sediment texture or benthic macroinfauna, that would indicate habitat differences caused by placement practices [for the Spring data].

.. the comparisons for the Fall data show no clear differences in benthic community statistics at PA and reference stations, with respect to either location (north-south trends) or elapsed time since the most recent dredging The infaunal assemblages censussed during September - October, 1996 were generally less diverse and less abundant than during the Spring throughout the Laguna Madre. In addition, there were no patterns of sediment texture that would reflect impacts, from placement activities sediment distributions - like infaunal communities appeared to vary independently of the location and age of previous dredged material placement, although there was a slight trend of decreasing sediment coarseness from north to south

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APPENDIX A

Taxonomic Species List

Spring 1996

ANNELIDA
OLIGOCHAETA
OLIGOCHAETA (LPIL)
POLYCHAETA
AMPHARETIDAE
AMPHARETIDAE (LPIL)
ISOLDA PULCHELLA
MELINNA CRISTATA
MELINNA MACULATA
ARABELLIDAE
DRILONEREIS LONGA
ARENICOLIDAE
ARENICOLA CRISTATA
CAPITELLIDAE
CAPITELLA CAPITATA
CAPITELLA JONESI
CAPITELLIDAE (LPIL)
HETEROMASTUS FILIFORMIS
MEDIOMASTUS (LPIL)
MEDIOMASTUS AMBISETA
MEDIOMASTUS CALIFORNIENSIS
NOTOMASTUS (LPIL)
NOTOMASTUS LATERICEUS
NOTOMASTUS LOBATUS
CHAETOPTERIDAE
SPIOCHAETOPTERUS OCULATUS
CHRYSOPETALIDAE
BHAWANIA HETEROSETA
CIRRATULIDAE
CAULLERIELLA (LPIL)
CHAETOZONE (LPIL)
CIRRATULIDAE (LPIL)
MONTICELLINA DORSOBRANCHIALIS
THARYX ACUTUS
COSSURIDAE
COSSURA SOYERI
DORVILLEIDAE
DORVILLEIDAE (LPIL)
PETTIBONEIA DUOFURCA
SCHISTOMEPINGOS CF RUDOLPHI
EUNICIDAE
EUNICIDAE (LPIL)
LYSIDICE SP D
MARPHYSA (LPIL)
MARPHYSA SP B
MARPHYSA SP E
MARPHYSA SP F
FLABELLIGERIDAE

FLABELLIGERIDAE (LPIL)

PIROMIS ROBERTI
GLYCERIDAE
GLYCERA (LPIL)
GLYCERA AMERICANA
GONIADIDAE
GLYCINDE SOLITARIA
GONIADA LITTOREA
GONIADA MACULATA
GONIADIDAE (LPIL)
HESIONIDAE
HESIONIDAE (LPIL)
PODARKE (LPIL)
PODARKE SP D
PODARKEOPSIS LEVIFUSCINA
LUMBRINERIDAE
SCOLETOMA VERRILLI
MAGELONIDAE
MAGELONA PETTIBONEAE
MAGELONA SP H
MAGELONA SP I
MALDANIDAE
ASYCHIS ELONGATUS
AXIOTHELLA SP A
CLYMENELLA TORQUATA
MALDANIDAE (LPIL)
NEPHTYIDAE
AGLAOPHAMUS VERRILLI
NEPHTYIDAE (LPIL)
NEPHTYS PICTA
NEREIDAE
CERATONEREIS (LPIL)
CERATONEREIS IRRITABILIS
NEREIDAE (LPIL)
NEREIS (LPIL)
NEREIS FALSA
NEREIS MICROMMA
NEREIS SUCCINEA
PLATYNEREIS DUMERILLI
ONUPHIDAE
DIOPATRA CUPREA
KINBERGONUPHIS SP B
KINBERGONUPHIS SP C
ONUPHIDAE (LPIL)
RHAMPHOBRACHIUM SP E
OPHELIIDAE
ARMANDIA AGILIS
ARMANDIA MACULATA
ORBINIIDAE

LEITOSCOLOPLOS (LPIL)

LEITOSCOLOPLOS FOLIOSUS
LEITOSCOLOPLOS FRAGILIS
LEITOSCOLOPLOS ROBUSTUS
NAINERIS DENDRITICA
ORBINIIDAE (LPIL)
PROSCOLOPLOS SP A
SCOLOPLOS RUBRA
OWENIIDAE
GALATHOWENIA OCULATA
OWENIA FUSIFORMIS
PARAONIDAE
ARICIDEA (LPIL)
ARICIDEA PHILBINAE
ARICIDEA SP E
ARICIDEA TAYLORI
ARICIDEA WASSI
CIRROPHORUS (LPIL)
CIRROPHORUS LYRA
LEVINSENIA GRACILIS
PARAONIDAE (LPIL)
PECTINARIIDAE
PECTINARIA (LPIL)
PECTINARIA GOULDII
PECTINARIIDAE (LPIL)
PHYLLODOCIDAE
ETEONE (LPIL)
EUMIDA SANGUINEA
HYPERETEONE HETEROPODA
NEREIPHYLLA FRAGILIS
PHYLLODOCE ARENAE
PHYLLODOCIDAE (LPIL)
PILARGIDAE
LITOCORSA ANTENNATA
PARANDALIA TRICUSPIS
SIGAMBRA TENTACULATA
SYNELMIS (LPIL)
POLYNOIDAE
LEPIDONOTUS VARIABILIS
MALMGRENIELLA SP A
MALMGRENIELLA SP B
POLYNOIDAE (LPIL)
SABELLARIIDAE
SABELLARIA FLORIDENSIS
SABELLIDAE
CHONE (LPIL)
DEMONAX (LPIL)
DEMONAX MICROPHTHALMUS
FABRICINUDA (LPIL)
FABRICINUDA TRILOBATA

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- NOTAULAX SP A
- POTAMETHUS (LPIL)
- SABELLIDAE (LPIL)

SERPULIDAE
- HYDROIDES DIANTHUS
- POMATOCEROS AMERICANUS
- SERPULIDAE (LPIL)

SIGALIONIDAE
- STHENELAIS BOA
- STHENELAIS SP A

SPIONIDAE
- APOPRIONOSPIO PYGMAEA
- CARAZZIELLA HOBSONAE
- DISPIO UNCINATA
- MALACOCEROS VANDERHORSTI
- PARAPRIONOSPIO PINNATA
- POLYDORA (LPIL)
- POLYDORA CORNUTA
- POLYDORA SOCIALIS
- PRIONOSPIO (LPIL)
- PRIONOSPIO HETEROBRANCHIA
- SCOLELEPIS (LPIL)
- SCOLELEPIS SQUAMATA
- SCOLELEPIS TEXANA
- SPIO (LPIL)
- SPIO PETTIBONEAE
- SPIONIDAE (LPIL)
- SPIOPHANES BOMBYX
- STREBLOSPIO BENEDICTI

SPIRORBIDAE
- SPIRORBIS SPIRILLUM

SYLLIDAE
- AUTOLYTUS (LPIL)
- AUTOLYTUS SP A
- DENTATISYLLIS (LPIL)
- EXOGONE DISPAR
- GRUBEOSYLLIS CLAVATA
- HAPLOSYLLIS SPONGICOLA
- PIONOSYLLIS (LPIL)
- SPHAEROSYLLIS (LPIL)
- SPHAEROSYLLIS TAYLORI
- STREPTOSYLLIS PETTIBONEAE
- SYLLIDAE (LPIL)
- SYLLIDES BANSEI
- SYLLIS (LPIL)
- SYLLIS BROOMENSIS
- SYLLIS LUTEA
- SYLLIS SP A

TEREBELLIDAE
- EUPOLYMNIA SP A

LYSILLA (LPIL)
PISTA PALMATA
PISTA SP E
STREBLOSOMA HARTMANAE
TEREBELLA RUBRA
TEREBELLIDAE (LPIL)
TRICHOBRANCHIDAE
TEREBELLIDES SP A
ARTHROPODA (CRUSTACEA)
AMPHIPODA
AMPHIPODA (LPIL)
AEGINELLIDAE
AEGINELLIDAE (LPIL)
DEUTELLA INCERTA
PARACAPRELLA (LPIL)
PARACAPRELLA TENUIS
AMPELISCIDAE
AMPELISCA (LPIL)
AMPELISCA ABDITA
AMPELISCA SP C
AMPELISCA VADORUM
AMPELISCIDAE (LPIL
AMPHILOCHIDAE
AMPHILOCHIDAE (LPIL)
GITANOPSIS (LPIL)
GITANOPSIS LAGUNA
AMPITHOIDAE
AMPITHOE (LPIL)
AMPITHOE LONGIMANA
AMPITHOIDAE (LPIL)
CYMADUSA COMPTA
AORIDAE
AORIDAE (LPIL)
GRANDIDIERELLA BONNIEROIDES
LEMBOS (LPIL)
LEMBOS TEMPUS
LEMBOS UNICORNIS
BATEIDAE
BATEA CATHARINENSIS
CAPRELLIDAE
CAPRELLA (LPIL)
CAPRELLA PENANTIS
COROPHIIDAE
COROPHIUM (LPIL)
COROPHIUM LOUISIANUM
COROPHIUM SP I
COROPHIUM SP O
COROPHIUM SP Q

GAMMARIDAE
GAMMARUS MUCRONATUS

ISAEIDAE
- ISAEIDAE (LPIL)
- MICROPROTOPUS (LPIL)
- MICROPROTOPUS RANEYI
- PHOTIS (LPIL)
- PHOTIS PUGNATOR

ISCHYROCERIDAE
- CERAPUS (LPIL)
- CERAPUS BENTHOPHILUS
- CERAPUS TUBULARIS
- ERICHTHONIUS BRASILIENSIS
- ISCHYROCERIDAE (LPIL)

LILJEBORGIIDAE
- LISTRIELLA (LPIL)
- LISTRIELLA BARNARDI

MELITIDAE
- DULICHIELLA SP B
- ELASMOPUS (LPIL)
- ELASMOPUS LEVIS
- MELITA (LPIL)
- MELITIDAE (LPIL)

OEDICEROTIDAE
- MONOCULODES NYEI
- MONOCULODES SP D

SYNOPIIDAE
- METATIRON TRIOCELLATUS
- TIRON (LPIL)
- TIRON TROPAKIS

CUMACEA
- CUMACEA (LPIL)

BODOTRIIDAE
- BODOTRIIDAE (LPIL)
- CYCLASPIS (LPIL)
- CYCLASPIS VARIANS

DIASTYLIDAE
- DIASTYLIDAE (LPIL)
- OXYUROSTYLIS (LPIL)
- OXYUROSTYLIS SMITHI

LEUCONIDAE
- LEUCON AMERICANUS
- LEUCONIDAE (LPIL)

DECAPODA (NATANTIA)
- DECAPODA NATANTIA (LPIL)

ALPHEIDAE
- ALPHEIDAE (LPIL)
- ALPHEUS ESTUARIENSIS
- ALPHEUS HETEROCHAELIS
- ALPHEUS NORMANNI

HIPPOLYTIDAE
- HIPPOLYTE (LPIL)

HIPPOLYTE ZOSTERICOLA
HIPPOLYTIDAE (LPIL)
PALAEMONIDAE
PALAEMONETES INTERMEDIUS
PENAEIDAE
PENAEUS AZTECUS
PROCESSIDAE
PROCESSA (LPIL)
PROCESSIDAE (LPIL)
DECAPODA (REPTANTIA)
DECAPODA REPTANTIA (LPIL)
DIOGENIDAE
CLIBANARIUS VITTATUS
PAGURIDAE
PAGURIDAE (LPIL)
PAGURUS (LPIL)
PINNOTHERIDAE
PINNIXA (LPIL)
PINNIXA RETINENS
PINNOTHERIDAE (LPIL
PORCELLANIDAE
EUCERAMUS PRAELONGUS
PORTUNIDAE
CALLINECTES SIMILIS
XANTHIDAE
NEOPANOPE TEXANA
XANTHIDAE (LPIL)
ISOPODA
ANTHURIDAE
MALACANTHURA SP B
HYSSURIDAE
HYSSURIDAE (LPIL)
XENANTHURA BREVITELSON
IDOTEIDAE
EDOTIA TRILOBA
ERICHSONELLA ATTENUATA
ERICHSONELLA FILIFORMIS
IDOTEIDAE (LPIL)
SPHAEROMATIDAE
DYNAMENELLA (LPIL)
DYNAMENELLA ACUTITELSON
HARRIETA FAXONI
PARACERCEIS CAUDATA
SPHAEROMATIDAE (LPIL)
MYSIDACEA
MYSIDAE
AMERICAMYSIS BAHIA
BOWMANIELLA (LPIL)

BOWMANIELLA BRASILIENSIS

MYSIDAE (LPIL)
OSTRACODA
OSTRACODA (LPIL)
CYTHERIDEIDAE
HAPLOCYTHERIDEA SETIPUNCTATA
SARSIELLIDAE
EUSARSIELLA DISPARALIS
EUSARSIELLA SPINOSA
EUSARSIELLA TEXANA
EUSARSIELLA ZOSTERICOLA
SARSIELLIDAE (LPIL)
TANAIDACEA
APSEUDIDAE
CALOZODION WADEI
LEPTOCHELIDAE
LEPTOCHELIA (LPIL)
PARATANAIDAE
HARGERIA RAPAX
PARATANAIDAE (LPIL)
ARTHROPODA (INSECTA)
EPHEMEROPTERA
EPHEMEROPTERA (LPIL)
CNIDARIA
ACTINIARIA
ACTINIARIA (LPIL)
ECHINODERMATA
ASTERIODEA
LUIDIIDAE
LUIDIA CLATHRATA
ASTEROIDEA
ASTEROIDEA (LPIL)
HOLOTHUROIDEA
HOLOTHUROIDEA (LPIL)
CUCUMARIIDAE
CUCUMARIIDAE (LPIL)
THYONELLA (LPIL)
THYONELLA PERVICAX
PHYLLOPHORIDAE
PHYLLOPHORIDAE (LPIL)
SYNAPTIDAE
LEPTOSYNAPTA (LPIL)
SYNAPTIDAE (LPIL)
OPHIUROIDEA
OPHIUROIDEA (LPIL)
AMPHIURIDAE
AMPHIODIA ATRA
AMPHIURIDAE (LPIL)
OPHIACTIDAE

HEMIPHOLIS ELONGATA

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HEMICHORDATA
ENTEROPNEUSTA
BALANOGLOSSUS (LPIL)
MOLLUSCA
GASTROPODA
GASTROPODA (LPIL)
NUDIBRANCHIA (LPIL)
ACTEONIDAE
RICTAXIS PUNCTOSTRIATUS
ATYIDAE
ATYS RIISEANA
BUCCINIDAE
BUCCINIDAE (LPIL)
CANTHARUS CANCELLARIUS
BULLIDAE
BULLA STRIATA
CAECIDAE
CAECIDAE (LPIL)
CAECUM PULCHELLUM
CALYPTRAEIDAE
CALYPTRAEIDAE (LPIL)
CREPIDULA (LPIL)
CREPIDULA FORNICATA
CREPIDULA MACULOSA
CREPIDULA PLANA
CERITHIIDAE
BITTIUM VARIUM
CERITHIUM LUTOSUM
COLUMBELLIDAE
ANACHIS OBESA
ANACHIS SEMIPLICATA
COLUMBELLIDAE (LPIL)
MITRELLA LUNATA
EPITONIIDAE
EPITONIUM (LPIL)
HAMINEIDAE
HAMINEIDAE (LPIL)
HAMINOEA ANTILLARUM
NASSARIIDAE
ILYANASSA TRIVITTATA
NASSARIUS (LPIL)
NASSARIUS VIBEX
NATICIDAE
NATICIDAE (LPIL)
NEVERITA DUPLICATA
NERITIDAE
NERITINA RECLIVATA
PYRAMIDELLIDAE

ODOSTOMIA (LPIL)

ODOSTOMIA IMPRESSA
ODOSTOMIA LAEVIGATA
ODOSTOMIA SP F
ODOSTOMIA WEBERI
PYRAMIDELLIDAE (LPIL)
TURBONILLA (LPIL)
TURBONILLA CONRADI
TURBONILLA PORTORICANA
TURBONILLA SP F
SCAPHANDRIDAE
ACTEOCINA (LPIL)
ACTEOCINA CANALICULATA
TURRIDAE
KURTZIELLA (LPIL)
PYRGOCYTHARA PLICOSA
TURRIDAE (LPIL)
VITRINELLIDAE
VITRINELLA FLORIDANA
VITRINELLA HELICOIDEA
VITRINELLIDAE (LPIL)
PELECYPODA
PELECYPODA (LPIL)
ARCIDAE
ANADARA TRANSVERSA
ARCIDAE (LPIL)
BARBATIA CANDIDA
CORBULIDAE
CORBULA (LPIL)
CORBULIDAE (LPIL)
CRASSATELLIDAE
CRASSINELLA LUNULATA
KELLIIDAE
ALIGENA TEXASIANA
LUCINIDAE
LUCINA MULTILINEATA
LUCINIDAE (LPIL)
LYONSIIDAE
LYONSIA HYALINA
LYONSIA HYALINA FLORIDANA
MACTRIDAE
MACTRA FRAGILIS
MACTRIDAE (LPIL)
MULINIA LATERALIS
MESODESMATIDAE
ERVILIA CONCENTRICA
MONTACUTIDAE
MYSELLA (LPIL)
MYSELLA PLANULATA

NEAEROMYA FLORIDANA

MYIDAE
SPHENIA ANTILLENSIS
MYTILIDAE
AMYGDALUM PAPYRIA
BRACHIDONTES EXUSTUS
BRACHIDONTES MODIOLUS
GEUKENSIA DEMISSA
MYTILIDAE (LPIL)
NUCULANIDAE
NUCULANA (LPIL)
NUCULANA ACUTA
OSTREIDAE
CRASSOSTREA VIRGINICA
OSTREA (LPIL)
OSTREA EQUESTRIS
OSTREIDAE (LPIL)
PECTINIDAE
ARCOPECTEN IRRADIANS AMPLICOST
SEMELIDAE
ABRA AEQUALIS
ABRA LIOICA
CUMINGIA TELLINOIDES
SEMELE PROFICUA
SEMELIDAE (LPIL)
SOLENIDAE
ENSIS DIRECTUS
TELLINIDAE
MACOMA TENTA
TELLINA (LPIL)
TELLINA LINEATA
TELLINA TAMPAENSIS
TELLINA TEXANA
TELLINA VERSICOLOR
TELLINIDAE (LPIL)
VENERIDAE
ANOMALOCARDIA AUBERIANA
CHIONE (LPIL)
CHIONE CANCELLATA
PITAR (LPIL)
VENERIDAE (LPIL)
POLYPLACOPHORA
POLYPLACOPHORA (LPIL)
PHORONIDA
PHORONIS (LPIL)
PLATYHELMINTHES
TURBELLARIA
TURBELLARIA (LPIL)
RHYNCHOCOELA
RHYNCHOCOELA (LPIL)

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LINEIDAE
    LINEIDAE (LPIL)
TUBULANIDAE
    TUBULANUS (LPIL)

SIPUNCULA
    SIPUNCULA (LPIL)
GOLFINGIIDAE
    PHASCOLION STROMBI

UROCHORDATA
ASCIDIACEA
    ASCIDIACEA (LPIL)

APPENDIX B

Taxonomic Species List

Fall 1996

TAXONOMIC LISTING

EHA - LAGUNA MADRE 03/19/97

Sept/October 1996

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ANNELIDA
- OLIGOCHAETA
  - OLIGOCHAETA (LPIL)
- POLYCHAETA
  - AMPHARETIDAE
    - HOBSONIA FLORIDA
    - MELINNA MACULATA
  - ARENICOLIDAE
    - ARENICOLA CRISTATA
  - CAPITELLIDAE
    - CAPITELLA CAPITATA
    - CAPITELLA JONESI
    - CAPITELLIDAE (LPIL)
    - HETEROMASTUS (LPIL)
    - HETEROMASTUS FILIFORMIS
    - MEDIOMASTUS (LPIL)
    - MEDIOMASTUS AMBISETA
    - MEDIOMASTUS CALIFORNIENSIS
    - NOTOMASTUS (LPIL)
    - NOTOMASTUS HEMIPODUS
    - NOTOMASTUS LOBATUS
  - CHAETOPTERIDAE
    - SPIOCHAETOPTERUS OCULATUS
  - CHRYSOPETALIDAE
    - BHAWANIA HETEROSETA
  - CIRRATULIDAE
    - CIRRATULIDAE (LPIL)
    - MONTICELLINA DORSOBRANCHIALIS
    - THARYX ACUTUS
  - COSSURIDAE
    - COSSURA DELTA
    - COSSURA SOYERI
  - DORVILLEIDAE
    - DORVILLEIDAE (LPIL)
    - OPHRYOTROCHA (LPIL)
    - PETTIBONEIA DUOFURCA
    - SCHISTOMERINGOS CF RUDOLPHI
    - SCHISTOMERINGOS PECTINATA
  - EUNICIDAE
    - LYSIDICE SP B
    - MARPHYSA SP B
    - MARPHYSA SP E
    - MARPHYSA SP F
  - FLABELLIGERIDAE
    - PIROMIS ROBERTI
  - GLYCERIDAE
    - GLYCERA AMERICANA
  - GONIADIDAE
    - GLYCINDE SOLITARIA

GONIADA LITTOREA
GONIADIDAE (LPIL)
HESIONIDAE
HESIONIDAE (LPIL)
PODARKE SP D
PODARKEOPSIS LEVIFUSCINA
LUMBRINERIDAE
SCOLETOMA (LPIL)
SCOLETOMA VERRILLI
MAGELONIDAE
MAGELONA (LPIL)
MAGELONA PETTIBONEAE
MAGELONA SP H
MAGELONA SP I
MALDANIDAE
ASYCHIS ELONGATUS
CLYMENELLA TORQUATA
EUCLYMENE SP B
MALDANIDAE (LPIL)
NEPHTYIDAE
NEPHTYS PICTA
NEPHTYS SIMONI
NEREIDAE
CERATONEREIS IRRITABILIS
NEREIDAE (LPIL)
NEREIS (LPIL)
NEREIS FALSA
NEREIS RIISEI
PLATYNEREIS DUMERILLI
OENONIDAE
DRILONEREIS LONGA
ONUPHIDAE
DIOPATRA (LPIL)
DIOPATRA CUPREA
MOOREONUPHIS CF. NEBULOSA
ONUPHIDAE (LPIL)
OPHELIIDAE
ARMANDIA MACULATA
ORBINIIDAE
LEITOSCOLOPLOS (LPIL)
LEITOSCOLOPLOS FRAGILIS
LEITOSCOLOPLOS ROBUSTUS
NAINERIS (LPIL)
NAINERIS DENDRITICA
NAINERIS SETOSA
NAINERIS SP.A
ORBINIIDAE (LPIL)
SCOLOPLOS (LPIL)

SCOLOPLOS RUBRA

OWENIIDAE
- GALATHOWENIA OCULATA

PARAONIDAE
- ARICIDEA (LPIL)
- ARICIDEA PHILBINAE
- ARICIDEA SP AE
- ARICIDEA SP E
- ARICIDEA SP X
- ARICIDEA TAYLORI
- CIRROPHORUS (LPIL)
- CIRROPHORUS LYRA
- PARAONIDAE (LPIL)

PECTINARIIDAE
- PECTINARIA (LPIL)
- PECTINARIA GOULDII

PHYLLODOCIDAE
- EUMIDA SANGUINEA
- HYPERETEONE HETEROPODA
- NEREIPHYLLA FRAGILIS
- PARANAITIS SPECIOSA
- PHYLLODOCIDAE (LPIL)

PILARGIDAE
- ANCISTROSYLLIS SP.B
- CABIRA INCERTA
- LITOCORSA ANTENNATA
- PARANDALIA TRICUSPIS
- PILARGIS BERKELEYAE

POLYNOIDAE
- MALMGRENIELLA SP A
- MALMGRENIELLA SP B

POLYODONTIDAE
- POLYODONTES FRONS

SABELLIDAE
- CHONE (LPIL)
- DEMONAX MICROPHTHALMUS
- FABRICINUDA TRILOBATA
- POTAMETHUS SP.A
- SABELLIDAE (LPIL)

SPIONIDAE
- APOPRIONOSPIO PYGMAEA
- CARAZZIELLA HOBSONAE
- DIPOLYDORA SOCIALIS
- PARAPRIONOSPIO PINNATA
- POLYDORA CORNUTA
- PRIONOSPIO (LPIL)
- PRIONOSPIO CIRRIFERA
- PRIONOSPIO HETEROBRANCHIA
- SCOLELEPIS TEXANA

- SPIO PETTIBONEAE

SPIONIDAE (LPIL)
SPIOPHANES BOMBYX
STREBLOSPIO BENEDICTI
SPIRORBIDAE
SPIRORBIS (LPIL)
SPIRORBIS SPIRILLUM
SYLLIDAE
AUTOLYTUS (LPIL)
AUTOLYTUS SP.A
BRANIA WELLFLEETENSIS
EXOGONE (LPIL)
EXOGONE DISPAR
EXOGONE ROLANI
GRUBEOSYLLIS CLAVATA
HAPLOSYLLIS SPONGICOLA
ODONTOSYLLIS ENOPLA
SPHAEROSYLLIS TAYLORI
SYLLIDAE (LPIL)
SYLLIDES BANSEI
SYLLIS (LPIL)
SYLLIS BROOMENSIS
SYLLIS DANIELI
TEREBELLIDAE
EUPOLYMNIA (LPIL)
PISTA (LPIL)
PISTA CRISTATA
PISTA PALMATA
STREBLOSOMA HARTMANAE
TEREBELLIDAE (LPIL)
TRICHOBRANCHIDAE
TEREBELLIDES SP.A
TRICHOBRANCHIDAE (LPIL)
ARTHROPODA (CRUSTACEA)
AMPHIPODA
AMPHIPODA (LPIL)
AEGINELLIDAE
AEGINELLIDAE (LPIL)
DEUTELLA INCERTA
AMPELISCIDAE
AMPELISCA (LPIL)
AMPELISCA ABDITA
AMPELISCA SP.C
AMPELISCA VADORUM
AMPHILOCHIDAE
AMPHILOCHIDAE (LPIL)
AMPHILOCHUS NEOPOLITANUS
GITANOPSIS LAGUNA
AMPITHOIDAE

CYMADUSA COMPTA

AORIDAE
    AORIDAE (LPIL)
    GRANDIDIERELLA BONNIEROIDES
    LEMBOS (LPIL)
    LEMBOS UNICORNIS
BATEIDAE
    BATEA (LPIL)
    BATEA CATHARINENSIS
COROPHIIDAE
    COROPHIUM (LPIL)
    COROPHIUM ACHERUSICUM
    COROPHIUM LOUISIANUM
ISAEIDAE
    MICROPROTOPUS RANEYI
ISCHYROCERIDAE
    CERAPUS (LPIL)
    CERAPUS TUBULARIS
    ERICHTHONIUS BRASILIENSIS
LILJEBORGIIDAE
    LISTRIELLA BARNARDI
MELITIDAE
    DULICHIELLA SP.B
    ELASMOPUS (LPIL)
    ELASMOPUS LEVIS
    MELITIDAE (LPIL)
OEDICEROTIDAE
    MONOCULODES SP.D
PHOXOCEPHALIDAE
    PHOXOCEPHALIDAE (LPIL)
SYNOPIIDAE
    TIRON TROPAKIS
CUMACEA
  BODOTRIIDAE
    CYCLASPIS VARIANS
  DIASTYLIDAE
    DIASTYLIDAE (LPIL)
    OXYUROSTYLIS (LPIL)
    OXYUROSTYLIS LECROYAE
    OXYUROSTYLIS SMITHI
DECAPODA (NATANTIA)
    DECAPODA NATANTIA (LPIL)
  ALPHEIDAE
    ALPHEUS ESTUARIENSIS
  HIPPOLYTIDAE
    HIPPOLYTE ZOSTERICOLA
  PALAEMONIDAE
    PALAEMONETES PUGIO
DECAPODA (REPTANTIA)

    DECAPODA REPTANTIA (LPIL)

PAGURIDAE
PAGURUS (LPIL)
PINNOTHERIDAE
PINNIXA (LPIL)
PINNIXA RETINENS
PINNIXA SP A
PINNOTHERIDAE (LPIL)
PORCELLANIDAE
EUCERAMUS PRAELONGUS
PORTUNIDAE
CALLINECTES (LPIL)
XANTHIDAE
NEOPANOPE TEXANA
XANTHIDAE (LPIL)
ISOPODA
ANTHURIDAE
ANTHURIDAE (LPIL)
MALACANTHURA SP B
HYSSURIDAE
XENANTHURA BREVITELSON
IDOTEIDAE
EDOTIA TRILOBA
ERICHSONELLA (LPIL)
ERICHSONELLA ATTENUATA
SPHAEROMATIDAE
HARRIETA FAXONI
SPHAEROMATIDAE (LPIL)
MYSIDACEA
MYSIDAE
BOWMANIELLA (LPIL)
OSTRACODA
PODOCOPA (LPIL)
CYLINDROLEBERIDIDAE
ASTEROPTERYGION OCULITRISTIS
CYTHERIDEIDAE
HAPLOCYTHERIDEA (LPIL)
SARSIELLIDAE
EUSARSIELLA SPINOSA
EUSARSIELLA TEXANA
EUSARSIELLA ZOSTERICOLA
TANAIDACEA
TANAIDACEA (LPIL)
APSEUDIDAE
CALOZODION WADEI
PARATANAIDAE
HARGERIA RAPAX
BRYOZOA
BRYOZOA (LPIL)

CNIDARIA
ACTINIARIA
ACTINIARIA (LPIL)

ECHINODERMATA
HOLOTHUROIDEA
HOLOTHUROIDEA (LPIL)
CUCUMARIIDAE
THYONELLA GEMMATA
PHYLLOPHORIDAE
ALLOTHYONE MEXICANA
OPHIUROIDEA
OPHIUROIDEA (LPIL)
AMPHIURIDAE
AMPHIODIA TRYCHNA
AMPHIURIDAE (LPIL)
MOLLUSCA
GASTROPODA
GASTROPODA (LPIL)
NUDIBRANCHIA (LPIL)
ACTEONIDAE
RICTAXIS PUNCTOSTRIATUS
BULLIDAE
BULLA STRIATA
BULLIDAE (LPIL)
CAECIDAE
CAECUM JOHNSONI
CAECUM PULCHELLUM
CALYPTRAEIDAE
CREPIDULA (LPIL)
CREPIDULA MACULOSA
CERITHIIDAE
CERITHIIDAE (LPIL)
CERITHIUM (LPIL)
CERITHIUM LUTOSUM
DIASTOMA (LPIL)
DIASTOMA VARIUM
COLUMBELLIDAE
ANACHIS OBESA
ANACHIS SEMIPLICATA
MITRELLA LUNATA
FISSURELLIDAE
DIODORA CAYENENSIS
HAMINEIDAE
HAMINOEA ANTILLARUM
NASSARIIDAE
NASSARIUS ACUTUS
NASSARIUS VIBEX
NATICIDAE
NEVERITA DUPLICATA
NERITIDAE
NERITINA VIRGINEA

SMARAGDIA VIRIDIS

POTAMIDIDAE
CERITHIDEA (LPIL)
PYRAMIDELLIDAE
ODOSTOMIA (LPIL)
ODOSTOMIA IMPRESSA
ODOSTOMIA LAEVIGATA
PYRAMIDELLIDAE (LPIL)
SAYELLA (LPIL)
SAYELLA CROSSEANA
TURBONILLA (LPIL)
TURBONILLA CONRADI
TURBONILLA PORTORICANA
SCAPHANDRIDAE
ACTEOCINA CANALICULATA
SCAPHANDRIDAE (LPIL)
TRICOLIIDAE
TRICOLIA AFFINIS
TRUNCATELLIDAE
TRUNCATELLA CARIBAEENSIS
TURRIDAE
PYRGOCYTHARA PLICOSA
VITRINELLIDAE
CYCLOSTREMISCUS SUPPRESSUS
VITRINELLA (LPIL)
VITRINELLA HELICOIDEA
VITRINELLIDAE (LPIL)
GASTROPODA (OPISTHOBRANC
GASTROPODA (OPISTHOBRANC
GASTROPODA (OPISTHOBRANC (LPIL
PELECYPODA
PELECYPODA (LPIL)
ARCIDAE
ANADARA TRANSVERSA
CARDIIDAE
CARDIIDAE (LPIL)
LAEVICARDIUM MORTONI
CORBULIDAE
CORBULA (LPIL)
CRASSATELLIDAE
CRASSINELLA LUNULATA
KELLIIDAE
ALIGENA TEXASIANA
LUCINIDAE
ANODONTIA ALBA
LUCINA MULTILINEATA
LUCINIDAE (LPIL)
LYONSIIDAE
LYONSIA (LPIL)

LYONSIA HYALINA FLORIDANA

MACTRIDAE
- MACTRA FRAGILIS
- MACTRIDAE (LPIL)
- MULINIA LATERALIS

MONTACUTIDAE
- MYSELLA PLANULATA

MYTILIDAE
- AMYGDALUM PAPYRIA
- GEUKENSIA DEMISSA
- LIOBERUS CASTANEUS
- MUSCULUS LATERALIS
- MYTILIDAE (LPIL)

NUCULANIDAE
- NUCULANA ACUTA

PERIPLOMATIDAE
- PERIPLOMA MARGARITACEUM

SEMELIDAE
- ABRA AEQUALIS
- CUMINGIA TELLINOIDES

SOLECURTIDAE
- TAGELUS PLEBEIUS

TELLINIDAE
- MACOMA (LPIL)
- MACOMA TENTA
- TELLINA (LPIL)
- TELLINA VERSICOLOR
- TELLINIDAE (LPIL)

VENERIDAE
- ANOMALOCARDIA AUBERIANA
- CHIONE (LPIL)
- CHIONE CANCELLATA
- VENERIDAE (LPIL)

POLYPLACOPHORA
- POLYPLACOPHORA (LPIL)

SCAPHOPODA

DENTALIIDAE
- DENTALIUM (LPIL)

PHORONIDA
- PHORONIS (LPIL)

PLATYHELMINTHES

TURBELLARIA
- TURBELLARIA (LPIL)

RHYNCHOCOELA
- RHYNCHOCOELA (LPIL)

LINEIDAE
- LINEIDAE (LPIL)

TUBULANIDAE
- TUBULANUS (LPIL)

SIPUNCULA
- SIPUNCULA (LPIL)

GOLFINGIIDAE
PHASCOLION STROMBI
SIPUNCULIDAE
SIPUNCULIDAE (LPIL)
UROCHORDATA
ASCIDIACEA
ASCIDIACEA (LPIL)